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HEATING UP GLASS TANKS

By J. GAVIN CALLINAN

ABOUT seven years ago a questionnaire was prepared by a clay company* and mailed to glass manufacturers. Eleven of the questions pertained directly to the problem of heating up glass tanks. The answers received were on the whole interesting and, as noted at the time in the published report of the questionnaire, showed that there was a certain amount of regularity and system applied to the problem, though there was considerable variety among the answers.

To the first question, twenty-one replied that they had a regular schedule for heating up their tanks and only six replied that they had no schedule or else adhered to no definite one. There was not much agreement on the remainder of the questions, as was to be expected. The tanks in question varied from small to large and were of many different designs. Even tanks built from the same blueprint failed to perform exactly the same; and usually even the same tank never quite duplicated the performance of the previous heat-up and fire. In all cases no specific instructions can be laid down as to just how to heat up a tank. The judgment of the furnace operator must be followed as it is given day by day on the job from experience and continual keen observation.

Despite the inability to lay down specific instructions to cover all cases, nevertheless, there are some major points, precautions and methods that are common to all cases, and it is with these that the following comments deal.

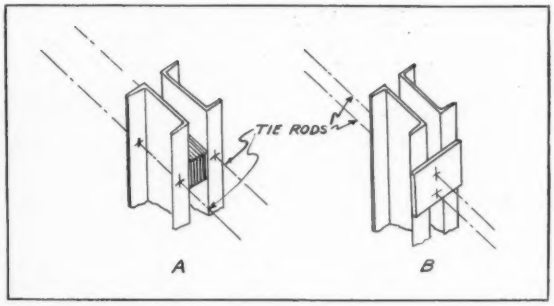
It is not difficult to heat up a tank without having a disaster but it is an exacting job to heat up a tank so that it will be in the best possible condition as to joints, cracks, iron-work and contents when it is ready to produce. And this heating up must be done without waste of time or fuel. Aside from the natural pride to be taken in doing a good job, the heat-up can often have an effect upon the quality of the initial production and on the ultimate life of the tank.

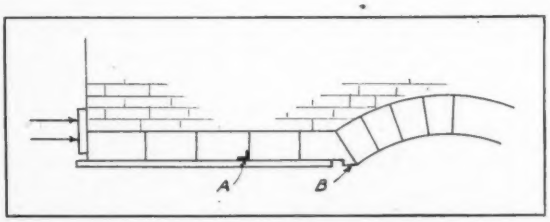
On large tanks the job of heating up cannot be done by one man, and the success then depends upon the way it is organized and supervised.

First, it is necessary to keep and refer to records of previous heat-ups and copies of instructions issued at that time, without being bound to do in the present what was done in the past. With ever-temperamental tanks one cannot use last year's schedule of events and make a real success of the heat-up. The records are valuable however, as reminders of things not to forget, preparations to make, details to inspect and results to watch for.

Second, the men who heat up should keep a log, not too detailed, yet sufficient to tell the oncoming shift what happened of importance during their absence, as well as to provide a record of observations that can be referred to the next time the tank is heated up.

In addition, plainly written instructions can profitably be given day by day or even shift by shift, so that nothing is left to memory or chance. Copies of these should be preserved with the log. It is well to have the shift leader initial the instructions and if there are any specific jobs to be done, to initial them as listed on the sheet after they have been completed. It is generally unwise to set up clerical work or red tape for the workers, but nevertheless practical experience has shown that some simple system as given above enables the men to understand that the heat-up is an important undertaking, and that it has the close and active supervision of the "boss" and is not merely one of the dirty jobs left for the old-timers to tackle. The men to whom the written instructions are issued unconsciously acquire a feeling of importance and carry on with the job in a





Figs. 1 (top) and 2.

* "Some Aspects of American Glass Tank Practice" by Fred S. Thompson and the Buckeye Clay Pot Co., Toledo, Ohio.

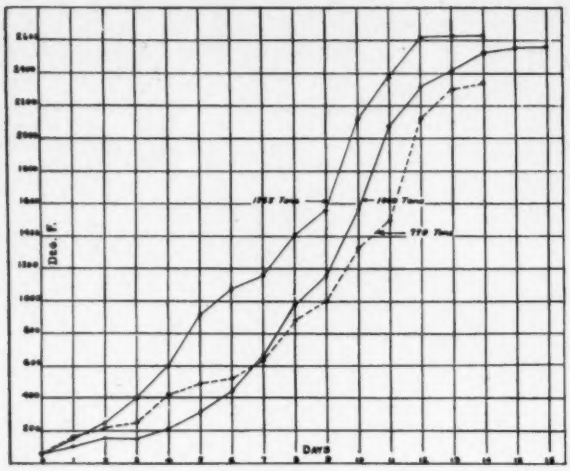


Fig. 3.

much better spirit, all the while accomplishing the purpose of the instructions which was to get the job done promptly and to get it done right.

Third, close supervision in the nature of a continual and personal check-up of details is necessary. At the best, the job of heating up is a dirty one and, on a large tank, a busy one. After the temperature passes 1000° F., some of the hot or difficult-to-get-at jobs will be slighted or ignored by the men with the feeling and hope that the next shift will get them done. When the men know that the superintendent or chief furnace operator personally checks up on every shift and is not backward about telling them of their errors of commission or ommission, they will not neglect the dirty jobs.

Considerable can be done before the fires are lit that later on will help materially. Such commonplace details as putting penetrating oil on all threads of the rods, nuts and turnbuckles, having all necessary wrenches handy in one place, erecting sufficient temporary lights in place, providing ample and safe scaffolding around the buckstays, checking fuel lines and valves for leaks, are all too often put off until the fire is on. Thus either the real job of taking care of the tank is slowed up or neglected, or else the job put-off is only halfway done, because of haste or heat from the tank.

Certain details of construction should, of course, properly be changed in ample time if records from the previous heat-up showed them to be poor in operation. This is where records of the experience during the previous heat-up are valuable. In one case, a tank was heated up whose melting end crown rods were as shown in A, Fig. 1. As a matter of fact, the men heating up had difficulty with these rods. They could not get the proper feel and at any time the buckstays all had varying degrees of twist. The method shown in B, Fig. 1, is more common, and certainly is a pleasure to work with, compared to the other. This particular detail would not give experienced men much trouble; but whenever equipment is arranged so that a job can be done more easily and with less uncertainty the surer it is that it will be done not only right, but promptly.

In another instance when heating up a tank, the dog house arch failed to respond as expected and investigation showed angles welded to the back wall plates, over which the plate blocks had been cut and laid as shown at A in Fig. 2. This held the arch and consequently considerable spalling occurred at B. It is remarkable how many times this and similar items of incorrect construction remain unchanged from fire to fire, because of the lack of a written note.

Crown markers should be put up in place in ample time; and it should be a rule that everyone keep off the crown after the fires are lit. Strap iron suitably bent, painted black, with white marks at half-inch intervals, are about the simplest markers. Rod irons suspended from overhead, with their ends painted white, serve as fixed points.

The final clean-up inside the tank is another easy job that nevertheless requires a check-up. Expansion joints, doors and various working openings should be cleaned out carefully and the underside of all new crowns should be brushed free of any loose cement. Invariably, when a last personal check-up is made, nails can be found driven into joints in the crown and broken electric light bulbs or some pieces of brick can be found half hidden in some corner. It always pays to check up.

The bottom should be closely inspected and if any wide cracks are discovered they must be cleaned out and covered with a piece of strap iron. This is easy to do on a cold tank and it may save a hard fight later with a bad bottom leak.

Finally an imaginative check-up should be made outside the tank. By that, is meant to take any part of the tank and its equipment and try to visualize how it will work while the tank is being heated up. On one such check-up, the large overhead natural gas main was found to be fixed securely to the tops of the buckstays and subsequent movement during the heat-up would have put a severe strain on some of the pipe joints. Another time, a steel walkway, that had been put in during the previous fire to permit repair men to set water coolers on the tank blocks, was welded tight between the feet of the tank buckstays and the regenerator irons. With a new bottom to heat up, trouble could be expected from this construction because, due to its particular design, it was necessary to allow the bottom of the buckstays to move out in order to make way for bottom expansion.

Tanks are heated up with or without cullet and it would seem that the empty-tank plan is best. Although, as is usual in a glass factory, circumstances alter cases, and with time and money to save at the start it is customary to fill the tank partially before heating up.

If cullet is to be used, the best practice is to heap it up in the center not higher than the tops of the flux blocks and to taper it down to the bottom at the side walls. This gives the side wall flux blocks the benefit of the heat, according to schedule. If the side wall blocks are thoroughly covered there is a strong possibility that they will receive a thermal shock and develop cracks that will hasten the destruction of the blocks during service.

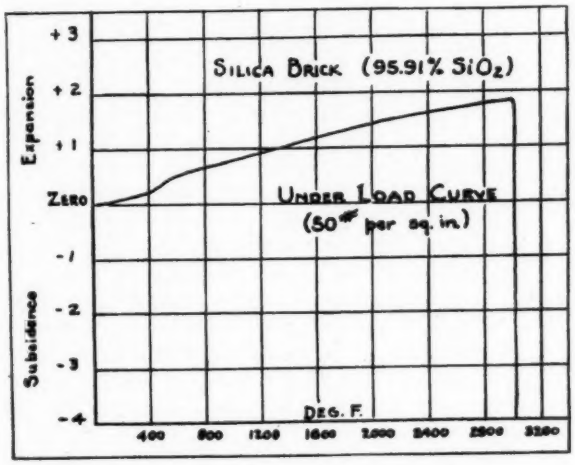
Cullet should not be put into the dog house. Some tank men have had experience with a frozen dog house and most have had experience at some time or another with a cold one. Heating up with cullet in the dog house is almost sure to cause the trouble which all will

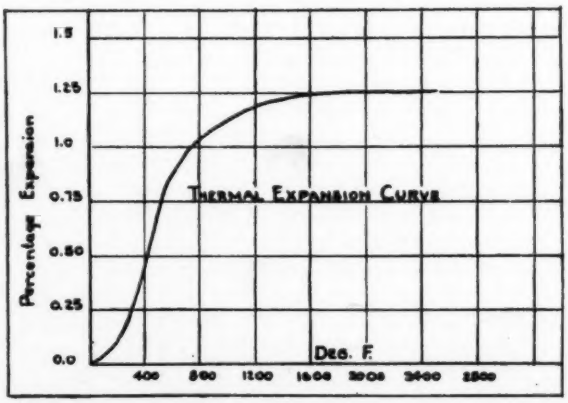
agree is one to avoid. In some plants the dog house is covered with large refractory tile during the first stages of the heat-up and later with a water-cooled cover. This latter, with large charges of cold cullet, will cause considerable extra work. A better arrangement is to have a brick arch built into an angle-iron frame work with one side closed. This can be lifted off and on by a balanced overhead arrangement. Or, if the regular charging equipment interferes, a suitably balanced floater wagon or a heavy lifting rod balanced from an overhead monorail can be utilized to take off the portable arch each time a charge is put into the tank.

When necessary, because of lack of kiln space, burnt floaters or other clay shapes can be heated up in the tank. Ordinarily the fuel savings are more than offset by the extra corrosion taking place before production of ware is begun.

The method of applying the first fires depends largely upon the size of the tank and the conveniences at hand. With natural gas, a perforated burner should be used in the tunnels, especially below the regenerators, if any of the brick work is new or if any of the old brick work is damp. These can be pulled out after the brick work is dry and warm so as to use no more fuel than is necessary.

When natural gas is used, the initial fire in the tank can be applied by means of pipes inserted through the burner block holes. In some plants the pipes are inserted between the flux blocks and the breast walls, but





Figs. 4 (top) and 5.

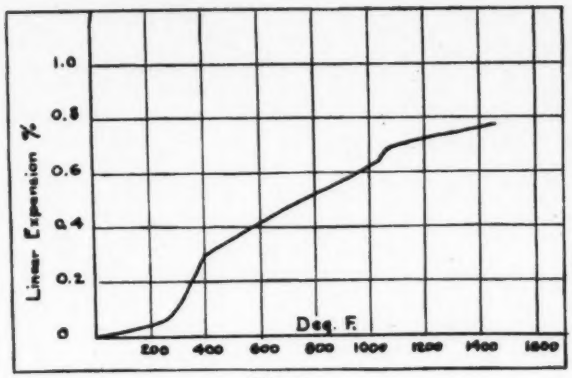


Fig. 6.

this is an awkward arrangement. Some plants use a long perforated pipe, entering at the dog house and extending down the tank, but this does not result in as even a heating as the first method mentioned. With any method a sufficient number of burners must be used in order to get as even a distribution of fire and heat as possible.

Oil is more difficult to handle and fewer burners can be used. They require closer attention at the start, but with proper burners selected to operate at low rates of fuel consumption and able to maintain a flame under relatively cold conditions, no great amount of trouble need be encountered.

If coal is used, fire boxes must be built against the sides of the regenerators, usually one below each port, and also against the working end of the tank. Temperatures can be brought up easily to schedule by this arrangement if trustworthy firemen are selected and properly instructed. Firing on alternate sides and in alternate fire boxes on any one side so as to get combustion within the tank, as in ceramic kilns, will bring a tank up to a temperature to take producer gas with a minimum of smoke and soot.

When using natural gas, the control is simple. Pipes inserted through the burner block holes can be connected by a hose to spuds and valves on a temporary supply line. Thus they can be turned or pulled back when they sag, as well as pulled back regularly as the tank heats up and as higher gas pressure is used which shoots the flame further into the tank. Caution must be exercised to watch the pipes for scaling, as jars will knock iron into the tank.

The same system can be applied to the refining and working ends of the tank, except that the pipes are inserted through various working or inspection openings. When this is done, the openings so used must be loosely bricked in. Invariably this bricking-in job is assigned to some laborer who will use the old silica bricks at hand. Aside from the higher cost of the silica, the resulting expansion of the brick, as it heats up with the tank, will jam them tight; and generally dirt gets into the tank when the bricks have to be removed by force. It is only a minor point, but it should not be allowed to happen.

The initial or warming-up fires are generally started before the tank work is quite completed. With a sufficient number of burners a gas flame four or five inches high will warm the tank while the last few odd jobs are being completed. Crown expansion joints should be

covered over with brick or tile. At times, to help clear up the fires a portion of an expansion joint can be uncovered so as to vent the tank. When this is done it should be carefully watched, as the flow of the hot gases will sometimes cause local hot spots with a resultant early expansion confined to a relatively small area of the crown.

Breast wall expansion joints should be closed with heavy cardboard or its equivalent, or else with light sheet metal bent into a "V" shape, so that it will collapse as the joint closes and be easily removable before the joint becomes too tight.

With all tank openings closed, the fires are ready to be increased and the temperature brought up on schedule time. Small tanks can be brought up nicely in ten days; whereas large tanks, with a standing capacity up to 1500 tons of glass, require twelve to sixteen days in which to be brought up to a temperature of 2600° F. These are safe schedules and may be speeded up if necessary, though longer heatings are desirable.

A ten day schedule that was used with very good results on an entirely new regenerative tank, which held 50 tons of glass, is given in Table I. These were the actual temperatures as taken.

TABLE I.

First day	7 A. M.	fires lighted
Second day	7 A. M.	250° F.
	11 P. M.	500° "
Third day	7 A. M.	600° "
	11 P. M.	850° "
Fourth day	7 A. M.	930° "
	11 P. M.	1050° "
Fifth day	7 A. M.	1100° "
	11 P. M.	1450° "
Sixth day	7 A. M.	1630° "
	11 P. M.	2100° "
Seventh day	7 A. M.	2240° "
	11 P. M.	2300° "
Eighth day	7 A. M.	2340° "
	11 P. M.	2550° "
Ninth day	7 A. M.	2550° "
	11 P. M.	2580° "
Tenth day	7 A. M.	2580° "

Considerable cullet was in this tank at the start and charging was started on the eighth day by adding five tons. Ten tons were charged on the ninth and tenth days, which brought the glass up to within a few inches of the top. The regular batch fill of 50 per cent batch and 50 per cent cullet was started on the 11th day while skimming was done and preparations for production were being made. This tank was clean when the fires were lighted and then it was heated thoroughly so that there was no possibility of cold corners or a cold bottom.

It should be mentioned here that temperatures in Table I were taken with a thermocouple protected by two porcelain sheaths so that the actual glass temperature was probably over 2600° F. when the tank was at maximum heat. In all cases due consideration must be given the location and method of taking temperatures, before comparing or attempting to duplicate temperature figures.

Table II gives the record of a large tank, 1000 tons capacity, that was heated up in sixteen days, including three days of warming up while final preparations were being made.

TABLE II.

First day	fires lighted	Ninth day	1150° F.
Second day	150° F.	Tenth day	1560° "
Third day	150° "	Eleventh day ..	2070° "
Fourth day	205° "	Twelfth day ...	2315° "
Fifth day	310° "	Thirteenth day..	2410° "
Sixth day	440° "	Fourteenth day.	2520° "
Seventh day ...	660° "	Fifteenth day...	2550° "
Eighth day	970° "	Sixteenth day..	2545° "

This record and several others are indicated in Figure 3. The tonnage figures shown represent the amount of glass the tanks hold and thus give an idea of their size. Of the three, the schedule curve for the 770-ton tank is the best, though it should be noted that all three show actual temperatures as recorded, and deviations were made from ideal schedules as circumstances arose.

The expansion curves for silica brick are well known and they can be used as a guide in arranging schedules; thought it must be remembered that the expansion as studied in a laboratory testing furnace is never the same as the expansion that takes place when the brick is under a varying load in a furnace crown and which is hot on one side and relatively cool on the other. Two curves, one for a silica brick under a load of fifty pounds per square inch and the other for free expansion are shown in Figs. 4 and 5. The total expansion to be expected will approximate ¾ to 1 inch in every five feet with the most rapid change probably occurring in the range 400°-800° F.

After 1300° F. is reached in a test, there is little further expansion; but it must be kept in mind that we may have expansion in a furnace crown after 1300° F. is reached, for the simple reason that a temperature instrument shows the temperature of the wire of the thermocouple. And after 1300° F., is indicated it takes some time for this heat to soak into the bricks.

With average firebrick or flux blocks, the expansion is more or less even up to 2000° F., although with a highly siliceous flux block containing considerable quartz, the expansion is irregular with rapid expansion occurring in the ranges of 150°-500° F. and 900°-1200° F. An expansion curve for such a flux block is shown in Figure 6. These curves vary depending upon how hard the block was originally burnt but the total expansion will approximate ⅜ to ½ inch in five feet.

Beyond 2000° F., refractory and flux material (especially more basic material) will shrink and attention must be paid to arches (especially jack or bridge arches), as up to 2400° F. the shrinkage may amount to between 1/16 and ⅛ inch in five feet. Above 2400° F. the rate of shrinkage may increase rapidly.

As the tank heats up, the crown must be gone over as often as once each hour. The best procedure is to check alternately each side of the tank, letting out on each rod until it is definitely loose, then taking up until it is barely snug, with the object of permitting only a slight rise in the arch. After this is done the flux block jack bolts must be checked and kept finger tight, because letting out the crown rods automatically releases the pressure of the jack bolts against the side wall blocks. Port irons where connected into the tank buckstays must be similarly checked.

Old tank bottoms require little attention but a new

(*Concluded on page* 154)

SHAPE — AN IMPORTANT FACTOR IN THE STRENGTH OF GLASS

By JAMES BAILEY

IT HAS long been recognized by engineers that shape has an important connection with the strength of any test piece. The matter was brought definitely to the front when automobiles came into general use. Experience demonstrated that sharp corners, key-ways or any sudden change in shape of a load carrying part gave rise to weaknesses which often resulted in the ultimate breakage of the parts of these places. An extensive study of this problem chiefly due to the research organizations of the industries serving the automotive field has now reached the point where the data taken may be advantageously studied and applied to the design of glass parts.

The more brittle the substance, the more necessary it is to consider the shape factor of strength. By the proper application of the ideas given below it is possible to increase the strength of a glass article to many times that of the designs often supplied to the market.

In order to get the most out of what follows, it is necessary to look upon glass as an elastic substance capable of deforming under any applied load. Viewed in this manner, it is evident that the strength as computed from the dimensions of the section and the constants of the material in the ordinary way does not always convey the true picture. Any sudden change in shape will result in a modification of the elastic behavior which tends to greatly alter both the direction and the magnitude of the stresses.

Actual analyses of the stresses around any change in shape are of an exceedingly complicated nature. Solutions to some of the simple cases of stress concentration produced around fillets, shoulders, collars and the like have been worked out mathematically. The mathematical analysis is beyond the powers of all but a few mathematicians and in any event is confined to relatively simple shapes. Another method which has recently been developed is based upon the bi-refringence produced by the strains in a transparent sample viewed by means of polarized light. This system is the bases of the common polariscope which is almost universally used in our glass works to determine the degree of strain.

Unfortunately the polariscope shows only the difference between the strains in the directions at right angles to the line of sight. It is perfectly possible to have tensile strains in the center of a sheet of glass and compression strains on the surface both of which are so great that the glass is in danger of spontaneous breakage and yet no strain can be seen in the polariscope except possibly a faint trace near the edge. Indeed, window glass drawn by the Fourcault process appears free from strain when viewed through the sheet but will show appreciable strains when viewed edgewise.

Bottles will sometimes appear to be relatively free from strain in the sides when viewed in the polariscope but a ring-section viewed edgewise will show considerable strain. These examples are given for three reasons. First they show that the interpretation of the strains seen in the polariscope requires considerable skill. Secondly, the actual strains are not seen at all—only their difference is visible. Thirdly, anyone wishing to study the concentration of stresses produced by shape factors such as collars, fillets, corners, sudden change in thickness as for example handles, bases, etc., must start with carefully annealed models.

In the study of stress concentration due to shape, glass is not a very convenient medium, both because of its low bi-refringence and because of the difficulty of making accurate models to test. Engineers usually use Bakelite,

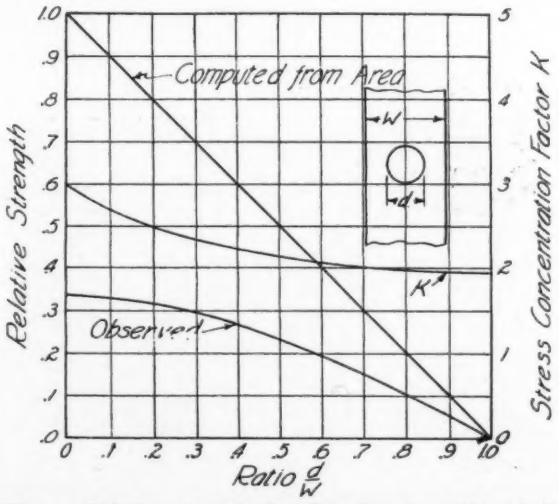


Fig. 1. Relative strength of a flat glass bar with a hole.

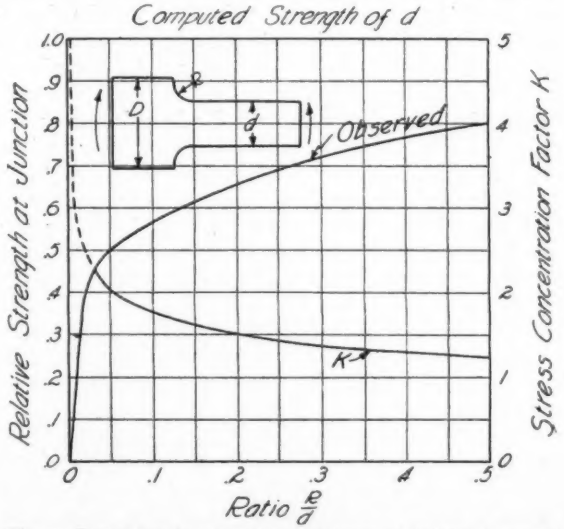


Fig. 2. Reduction in strength of a beam of height d, caused by increasing its height to D with a fillet R stressed by bending.

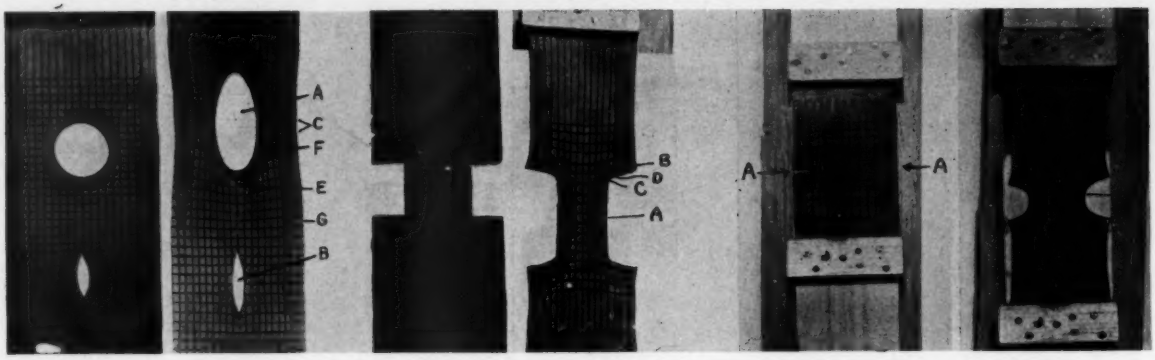


Fig. 3a. Fig. 3b. Fig. 4a. Fig. 4b. Fig. 5a. Fig. 5b.

In each group, the "a" specimen is normal and "b" slightly stretched. The first pair shows the strain concentration that occurs around a hole. Next, strain concentration caused by a sudden change in shape. (Right), strain concentration caused by a narrow slot.

Phenolite or celluloid. These materials can be machined in the ordinary shop and may be annealed with relative ease. A model made of any one of these may be held in the polariscope and an idea of the strains set up in practice may be gleaned by applying pressure on it with the hands. The results will be surprising. It will be seen that bright areas of strain develop wherever a small section joins a heavy section, and sudden bends will show heavy stress concentrations on the inside of the bend no matter what the direction of the applied force.

The exact measurement of these stresses required elaborate apparatus and a system of computation which cannot be discussed here. The results, however, are of prime importance to the designer of glassware.

Figure I, shows the reduction in strength caused by a hole of diameter "d" drilled through a flat plate of elastic material of width "w". It is evident that the hole removed some material and hence decreased the strength. The ordinary method of figuring strength from the area of material remaining gives the relative strength computed from the area. Photo-elastic measurements[1] show that the stress is not uniform across the section at the sides of the hole. The hole destroys the ability of the material immediately above and below to take the expected share of the load. It is actually compressed laterally and carries no load at the upper and lower edge of the hole. See Figure 3b.

The fact that the forces must divide and pass around the hole causes them to concentrate at the inner surfaces of the sides of the hole, with the result that the maximum stress is much greater than the average stress across the section. The relatively great separation of the lines near the hole on Figure 3b shows this stress concentration very nicely. The "K" line of Figure I shows the ratio of this maximum stress to the average stress. The important thing from the standpoint of the glass designer is that the maximum stress concentration occurs around a very small hole and results in a reduction of strength to one-third that of a solid bar having no hole. The above example is, essentially a two dimensional system since the shape factor does not affect the forces perpendicular to the paper. A bubble in a glass rod brings into play three dimensional stresses which are much more difficult to analyze. However, the stress concentration around a bubble must be less than that around the hole in the above example because the volume of material above and below a bubble of any diameter bears a much smaller ratio to the volume of the whole body of glass than is the case where a hole of the same diameter is bored through a rectangular bar. A small bubble therefore cannot be an important source of weakness since it can reduce the theoretical strength to some finite value such as half that of a hypothetically perfect piece whereas there are other factors which will reduce the strength practically to zero. However, a bubble is a very interesting thing and we shall have more to say about it later.

Figure 2, shows the result of changing the width from d to D with a square shoulder and fillet of radius R as shown, when a uniform bending moment is applied to the test piece. The stress concentration factors were obtained photo-elastically by E. E. Weibel[2]. If the strength is computed from the width d of the sample it would have a value of one (1.0). This would be constant since it is the smallest section of the test piece and remains unchanged for all values of R. Photo-elastic measurements however, show that the strains set up in the part d by the bending moment cannot pass smoothly around the corner into the heavier section which is much more rigid. There is a marked increase at the fillet and this increase depends upon the radius of the fillet. The curve K shows that the observed stress becomes very large when R is very small. If R were zero then the observed stress would be infinite. Hence the strength would become zero and a very small shock would result in breakage at the corner.

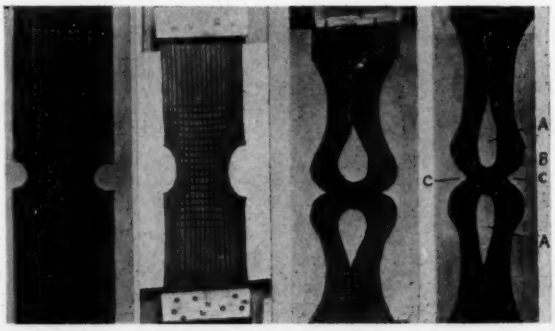


Fig. 6a. Fig. 6b. Fig. 7a. Fig. 7b.

(6) Strain distortions around a circular groove, and (7) in a complicated shape. (No. 7b. was also slightly bent).

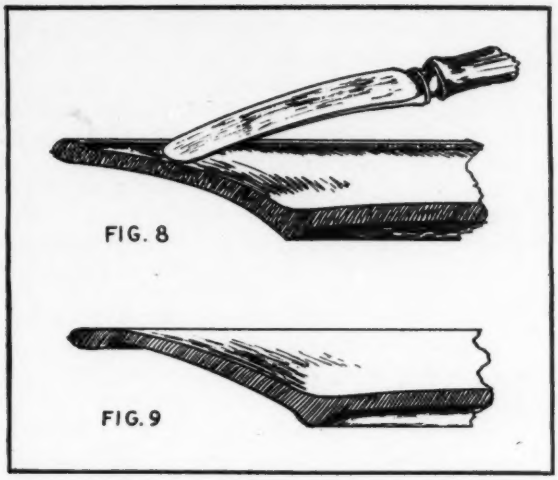


FIG. 8

FIG. 9

The application of this stress diagram to the design of a glass article is definite and decisive. No two sections of the glass should be joined together without a good substantial fillet at the union. This is often difficult of attainment in glass working especially in the art glass field. There is really no excuse for it in pressed glass articles because careful mold design can always overcome sharp angle union between the various faces of the glass.

The difficulty in art glass arises when hot glass is stuck onto a part already made. When the rounded end of the hot glass touches the colder glass it flattens out but a sharp angle is always formed between the two surfaces of the glass. Since the added glass is softer than the cooler glass the tendency is for the surfaces to chill in this shape. If, however, the article is finished and annealed in this condition it is very weak mechanically and entirely unfit for use. We have had samples of tea pots submitted to our laboratory which were perfectly annealed and were very nice examples of the glass workers art but they possessed this defect where the spout joined the bowl and where the handle joined the side. A sharp tap with a lead pencil was all that was required to break off the spout or to start a crack around the handle. The slightest thermal shock would have sufficed to start a crack at these points. It is a striking example of a shape defect, namely, the union of two parts without an adequate fillet at the union.

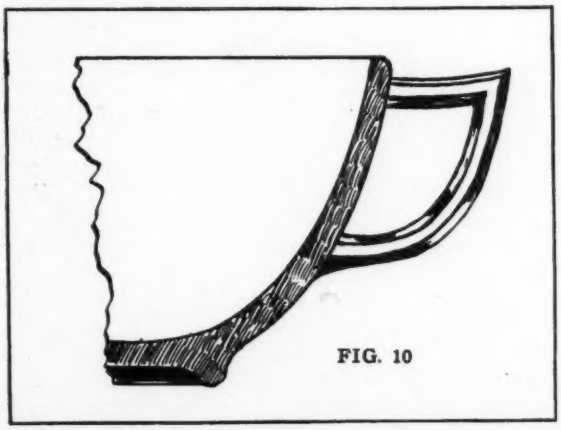


FIG. 10

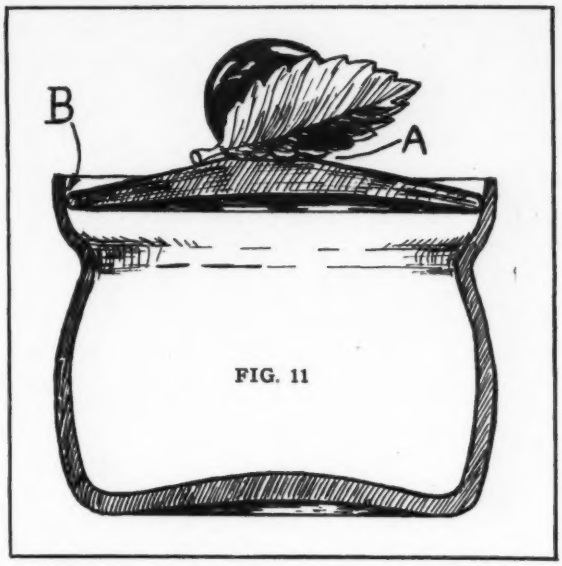


FIG. 11

It will be noted that the above defect arose when two parts were joined by pressing them together. In general any two soft pieces of glass pressed together will unite with a sharp reentrant angle because of the character of flow under these conditions. Fortunately, under tension the exact opposite effect is always produced. All that is necessary to overcome the difficulty with the spout and handle is to adjust the temperatures of the parts so that it is possible to draw out the region of the union and thus open out and destroy the sharp angle at the union. This requires a carefully worked out technique but can be easily and successfully done once the proper procedure has been established.

Another example of a shape defect often found is where a blown bowl is joined to a heavy glass foot by the pressing method. Some manufacturers have had considerable difficulty getting what they thought was a satisfactory union of these parts. In nearly all cases the weakness was a shape defect and not a glass defect. If the problem is looked upon from the standpoint of the relative rigidity of the parts joined together the reason for the weakness is immediately apparent. The bottom of the bowl was relatively flat and thin while the pressed part of the base was relatively heavy and stiff. When any load was applied the bottom of the bowl deflected while the heavy base resisted this deflection. The strain was therefore concentrated at some relatively small part of the outside of the union between the rigid base and the more flexible bottom. This union was sharp and the stress concentration so great that a crack was started. The solution in this case is to readjust the relative rigidity of the parts. Either the bottom of the blown bowl must be more rigid or the top of the base must be thinner and more flexible. Often both results may be accomplished by increasing the diameter of the part of the base that joins the bottom thus stiffening the bottom and at the same time reducing the magnitude of the stresses. Many problems which are baffling when viewed from the standpoint of strength alone becomes self evident when viewed from the standpoint of elastic deformation.

It is always difficult to measure strains with great accuracy. The most direct way is to measure the elongation or stretching of the material. This is not practicable in small regions of stress concentration when such materials as glass, bakelite and celluloid are used because of the small distance to be measured. Fortunately rubber stretches so easily that it enables the stresses in a specimen of any shape to be studied with relative ease. The results obtained are not exact since the stress-strain relation in rubber does not follow Hook's law. Also the change in shape modifies the strains and the stress concentrations found will always be somewhat low but a visual understanding can be obtained through the use of rubber models that is not obtainable in any other way. Anyone interested in this subject is advised to repeat the following experiments using rubber from an inner tube.

FIGURE 3b shows the result of stretching the ruled rubber shown in Figure 3a. It corresponds to the specimen used to obtain the curves in the Figure I. The original piece of rubber was ruled lengthwise and crosswise with straight lines. A round hole A having a diameter about 1/3 of the width was cut through it with a cork cutter. A hole B having in length about three times its width was also cut out. The rubber was then nailed between two pieces of wood and stretched to about one and one-quarter times its original length. The Figure 3b shows how unequally the stretching took place. It can be seen that the material at C has stretched very little more than the body of the rubber at G even though the hole A has removed nearly one third of the rubber at this section. The material at D, however, has been stretched very much more so that the strain at D is fully 80 per cent greater than at C. The material at E has not been stretched at all. It is, in fact, under lateral compression as indicated by the wrinkling at these places. The strain at F has so distorted the surface that one would scarcely recognize the original square.

The hole B was cut out to similate the shape of a bubble as often found in glass which has been pulled out during manufacture. The lines leading to a hole of this shape are much less distorted indicating a great reduction in the stress concentration as compared to a round hole.

Figure 4a, shows a piece of rubber cut out with square notches and ruled off in squares in its normal position. Figure 4b shows it after stretching slightly. It can be seen that the strain at A is uniform across the section indicated by straight lines. At B the material has actually been slightly compressed. The corners C have nearly rounded out and the distorted shape of the adjacent square D shows that the stress concentration at the original corner C is very great as was shown in Figure 2 by the photo-elastic method.

Figure 5a shows a piece of rubber in which have been cut two very narrow notches A. This same specimen is shown stretched in Figure 5b. Both illustrations are at the same scale. The total stretching was about half the length yet the rubber at B has been stretched to at least four times its initial value. The shape of the end of the lines at B should be noted. It indicates an exceedingly great stretching at the very end of the line. It is evident that a glass article having an opening around the union such as the above would have very little resistance to any breaking force whatever. This example illustrates the stress concentration around any re-entrant angle such as were present at the place where the spout and the handle were attached to the bowl of the tea-pot cited above. Figures 6a, and 6b show how the stress is relieved when the narrow slots of Figure 5a are rounded out to semi-circular notches. By giving the strains a chance to spread around the circular notch they have dropped to a point where they are nowhere more than one and one half times what they would have been had there been no notch.

Figures 7a and 7b, show what happens to a complicated shape as is sometimes found in stemware, when a tension and slight bending are applied. The whole configuration is thrown out of shape and numerous reversals of stress take place. The large hollow spaces A which at first thought might help strengthen the joint in reality prevent the central portion B from taking any load and all the forces are concentrated at the apex of the re-entrant angles C. A glass structure after this design would have almost no strength at all.

An almost limitless variety of designs would be studied with rubber models in the above manner. It is believed the few illustrated will serve the purpose of the present article, but anyone interested in the elastic concentration of the strains will do well to cut out some ruled models and observe their action when pulled and bent.

A crack in glass once started will spread with ease. This has often been the subject of discussion among glass men. The answer is apparent from the stress concentration curve of Figure 2. A cracked glass is a more pronounced case of two rigid sections joined together with a fillet of radius equal to zero. The forces set up in a cracked pane of glass tend to concentrate around the apex of the crack. The concentration is very difficult to observe in the polariscope because the area where the strain is greatest is very small. Under a petrographic microscope the strain can easily be seen but its real magnitude is masked unless the crack is square ended and absolutely perpendicular to the surface.

WHEN hot glass is worked, the flow follows the lines of force. No elastic stress concentration as discussed is possible, but the lines of force as shown in the rubber samples cause flow to take place more rapidly at the places where the stress is greatest. Pulling a sample of plastic glass will cause it to flow out into much the same shape as that indicated by a stretched rubber sample. All the sharp re-entrant angles will be opened out and sharp corners will be automatically replaced by fillets. Because of the stress concentration a relatively small movement is necessary. Usually any shape will be improved by drawing it out to some extent. Even small surface defects such as small wrinkles, checks and so forth will open out enough to materially reduce their detrimental effects.

It is sometimes worth while to be able to determine what the character of flow has been. This can be quite accurately determined from the shape of the seeds in the glass. They are always spherical in very hot glass. Any stretching of the glass after it has become stiff enough

to work will result in a distortion of the bubble. If the glass has been drawn out in one direction as in rods, tubing or drawn window glass, the bubble will have an elongated shape. This shape furnishes a measure of the amount and direction that the glass has been stretched. A blown article is stretched in two dimensions and the bubble will be flattened in one direction and elliptical in the two other directions but the flow in all three dimensions can be computed from its shape. A longitudinal bubble has almost no effect on the tensile strength, an elongated bubble resting crossways to an applied tensile stress will have a small effect upon the strength. A flattened bubble may be a dangerous source of weakness if the glass is strained so as to open out the flat sides of the bubble.

There are other shape factors which have an indirect affect on the strength and which reduce the serviceability of the article. Figure 8 shows a glass plate pressed right side up. The plunger has been pressed lower than the ring leaving a small rim. If this is at all sharp a chip can easily be knocked out by sliding the end of a knife against it. This fin should be well rounded by fire-polishing or the dish should be pressed upside down as shown in Figure 9.

Figure 10, shows a type of handle of poor design but which seems to be generally in vogue on pressed glass articles. The corners where the handle joins the bowl are made as sharp as possible instead of rounding them nicely. This design is supposed to be modernistic but it is an eye-sore to those who realize the strength limitations of glass. Figure 11, represents a jar with decorated cover which shows very poor design from the strength standpoint. The bowl is thin blown glass. The cover is pressed and much heavier and has been decorated by sticking on some glass fruit. Very bad re-entrant angles are shown at A. This cover will not stand common dish washing. The heat shocks are sooner or later sure to start cracks where the decoration is attached.

The wall of the bowl at B is tapered and the cover is so large that it seats against the taper. Expansion of the thin bowl permits the cover to slide down until it is firmly wedged in the taper. It is difficult to get the cover off without scratching the thin bowl. The tensile stresses set up in this design will result in ultimate breakage.

In conclusion it may be stated that strength and serviceability depend as much upon the shape as upon the inherent strength of the glass. Fundamentally the behavior of glass under stress is one of relative rigidity. A good idea of stress concentration can be had from the study of flexible models. Cooperation between the artist, the mold designer, the artisan and the management is required if shape defects are to be eliminated.

[1] A. M. Wahl and R. Beeuwkes, Jr. Trans. A.S.M.E. Vol. 56, No. 8. Aug. 1934. p. 617.
[2] Transactions A.S.M.E. Vol. 56, No. 8. p. 637. August 1934.

Larger window areas and skylights, and modern lighting equipment in industrial plants and in public buildings was advocated by Winifred Hathaway, Associate Director of National Society for the Prevention of Blindness, in Detroit last month.

GEORGE W. COOPER

With the profoundest sorrow, The GLASS INDUSTRY announces the death of George William Cooper, founder of this publication, on April 2, in London, Ontario. Death from heart failure followed a period of ill health lasting for nearly three years.

Mr. Cooper was born in London, Ontario, on February 13, 1873. His education was received in the schools of that city. Almost from the beginning, he evidenced a great fondness for art, a subject which he studied at the Mechanics Institute.

His first occupation was that of a wood engraver, being employed by the London Press, and so it was in the publishing business that he both began and ended his business career. Always interested in science, Mr. Cooper was an insatiable reader of scientific publications, and this led him to study bridge engineering. His ability here soon found recognition through a connection with the Buffalo Bridge Works and with the Boston Bridge Company. Moving to New York City, he then became the sales agent for a firm manufacturing concrete mixers and while so engaged made the acquaintance of the late Frank B. Gilbreth, and became his publicity manager.

In 1908, Mr. Cooper joined *Metal Industry* as its advertising manager, a position he held for the next sixteen years. His work brought him in occasional touch with glass manufacturing, and his desire to know more about glass making led to the discovery that the glass industry was not served by any journal dealing with its manufacturing and production phases. To fill this want, his entire background of experience was ideally fitted. He resigned his position to found The GLASS INDUSTRY.

Mr. Cooper was one of the kindliest of men—always unassuming and sincere. His personal qualities attracted men to him, and when ill health forced him to retire from active participation in his business, a few years before his death, few in the industry were better known or better liked. His loss will be keenly felt.

GAINS IN GLASS INDUSTRIES

The Survey of Current Business for April reports a marked increase in production and employment figures for the glass industry in general over last year. Taking the years 1923-25 as 100 for an index, plate glass production in February of this year is reported at 166 as compared to 98 for the same month of 1934. Employment in glass factories was 94.1 for February, 1935, as contrasted with 91.8 for the same month of the previous year. Payrolls stand at 75.6 as compared to 73.5 for February, 1934. This usual lag between production figures and employment figures would seem to indicate possibilities of further expansion in the glass industries.

Production figures indicate a definite upturn. The production of glass containers was 2,639 in thousands of gross, which is 49.9 per cent of capacity in February, 1935, and compares with 2,600 or 49.2 per cent for the same month of 1934. The production of illuminating glassware was 1,774 tons (65.6 per cent of full operation in February) as contrasted with 1,413 and 55.1 for February, 1934. Polished plate glass production showed a tremendous increase to 13,723 square feet in February from 7,441 square feet in the same month of the previous year.

EXTENSIVE TANK ALTERATIONS AT MARYLAND GLASS CORP.

The Simplex Engineering Co., Washington, Pa., has recently been awarded a contract covering extensive repairs and alterations to the plant of Maryland Glass Corporation, Baltimore, Md. Operations will start about May first and will require six or seven weeks for completion. The work will include rebuilding and raising a thirty ton tank to a twelve foot feeder level. The new tank is intended to provide a more flexible unit for the operation of Hartford-Empire I. S. machines on a balanced pull.

LIBBEY-OWENS-FORD PLANS EXPANSION

Libbey-Owens-Ford Glass Co. showed a net profit of $2,219,767 for the quarter ended March 31, after depreciation Federal taxes etc., as compared with $1,370,998 earned in the March quarter of 1934. The Company also announced a plan for $1,700,000 of improvements to its flat glass plants in East Toledo and Rossford (Ohio), Charleston, W. Va., Ottawa, Ill., and Shreveport, La., to increase safety glass capacity and warehousing space. The Company had 6,889 persons on its payroll during the first quarter of the year and as a result of increased wages and steadier work the average monthly income of workers was 18.4 per cent above the same period of 1934, according to John Biggers, president.

OWENS-ILLINOIS EARNINGS

At the annual meeting of shareholders of Owens-Illinois Glass Company held at Toledo, April 17, it was announced that net earnings of the Company and wholly owned subsidiaries for the twelve months' period ended March 31, 1935, were $6,427,074.78, as compared with $6,993,489.10 for the twelve months' period ended March 31, 1934.

In arriving at these earnings, deductions have been made for depreciation, depletion, repairs, Federal taxes and bad accounts. Depreciation and depletion have been charged against both operating and non-operating plants at the same rates as used in prior periods.

These earnings are equivalent to $5.36 per share on the 1,200,000 common shares outstanding, as compared with $5.41 per share earned for the twelve months' period ended December 31, 1934, and $5.77 per share for the twelve months' period ended March 31, 1934.

CORNING ADDS INSULATION EXPERT TO RESEARCH STAFF

Julius J. Torok, since 1925 with Westinghouse Electric & Manufacturing Company, has joined the Research and Development staff of Corning Glass Works. Mr. Torok will be located at the main plant of the company in Corning, New York. As an expert in the field of insulation engineering Mr. Torok will give particular attention to the development of applications of glass to electric insulation.

MARCH PLATE PRODUCTION

The production of Polished Plate Glass by members of the Plate Glass Manufacturers Association for the month of March, 1935, was 16,531,950 sq. ft., which makes a total of 43,620,289 sq. ft. for the first quarter of 1935.

U. S. DISCOVERS KYANITE DEPOSITS IN GEORGIA

A survey of the kyanite reserves of Georgia conducted during the summer of 1934 by the U. S. Geological Survey in cooperation with the Georgia Division of Geology led to the discovery of wide areas of a kyanite bearing mica schist and isolated areas of kyanite in other forms and occurrences such as dornicks, placers, and in quartzite.

The kyanite is found in the Piedmont area which is bounded by the Fall Line to the south and the Cartersville Fault to the northwest. The only areas producing at the present time are in Habersham County in northeast Georgia and these properties are part of a U-shaped belt extending over into Rabun County and having an overall length of about 30 miles and a width of 1000 feet or more. The average kyanite of the schists runs about 3 per cent iron and 3 per cent silica, but the placers yield a product containing only about 1 per cent iron. The Bureau of Mines is conducting experiments concerning the beneficiation of the schist material and predicts that this can be recovered and used when there is sufficient demand.

PITTSBURGH PLATE TO SPEND ANOTHER TWO MILLION ON PLANTS

H. S. Wherrett, President, Pittsburgh Plate Glass Company, has announced an additional program for plant extension, improvements and new equipment calling for an expenditure of $1,905,000. This, together with previous factory expenditures authorized for this year, brings the total appropriation for plant improvement of the Pittsburgh Plate Glass Company to $4,580,000. The largest item of this new appropriation provides for the installation of laminating equipment to make Duplate Safety Glass at the Company's plate glass factory at Crystal City, Missouri.

NEW APPARATUS FOR MEASURING THE VISCOSITY OF GLASS

By F. H. NORTON[1]

IT WAS thought that those carrying on studies in glass viscosity would be interested in the furnace recently developed at the Massachusetts Institute of Technology. This furnace is distinguished by a high precision and simplicity of construction. The temperature control is based on the recently described[2] apparatus now being used here for studying the creep of metals.

The recent work of Lillie has shown that the apparent viscosity of glass changes with time. In some cases the viscosity is still changing after many weeks of continuous test. Such changes are of great importance in studying the constitution of glass, but they can be accurately determined only with very close temperature control. The furnace described here is intended for this type of precision testing.

The Furnace. A cross section of the furnace is shown in Fig. 1. The test specimen (A) is a glass fibre about 1 mm. in diameter, held by austenitic steel holders (B) which are first slipped over the fibre and then the ends of the latter are formed into small spheres in a gas flame. The specimen and the holders are placed inside of the heavy steel tube (C) to which are attached the three chromel-alumel thermo-couples (D) for measuring the temperature along the specimen. This whole assembly is enclosed by the heavy walled steel furnace tube (E) which is wound with mica tape and chromel wire (F). This is insulated by a high temperature pipe cover (G) coated with aluminum foil. The winding is divided into three separate parts so that the temperature gradient can be accurately controlled.

The Loading. The loading is done by means of a dead weight acting directly on the lower holder. For a very light load the weight of the glass fibre itself must be taken into account.

The Temperature Regulation. The temperature is maintained at a constant value by the change in length of the furnace tube as follows. If the temperature increases, tube (E) expands, raising the casting (H) on the upper end, which lifts the lever (I) through the knife edges (J). A magnification of about 50 permits the opening of the contacts (K) with a very slight temperature change. This cuts out the resistance R_3 in parallel with R_4 and decreases the current about 10 per cent. In about 15 seconds the furnace has cooled enough to close the contacts and the cycle is repeated. The condenser C_1 prevents sparking.

The success of this control depends on maintaining a constant spacing between the lower casting (L) and the upper platform (M). This is accomplished by the rods (N) which are of invar or fused quartz. The temperature gradient along the specimen is adjusted by the parallel rheostats R_1 and R_2. For precision work a fairly constant room temperature is necessary. The furnace temperature is adjusted by turning the contact screw and then adjusting R_4 until the cycle is balanced.

The Measurement of Length. The measurement of length in most cases is carried out with the moving microscope (O), which is sighted upon a fine scratch on the weight rod. This method allows a large range of motion and quick setting where a precision of .0005 cms. is sufficient. For high viscosities the fibre eyepiece (P) can be used to give a reading to .00005 cms.

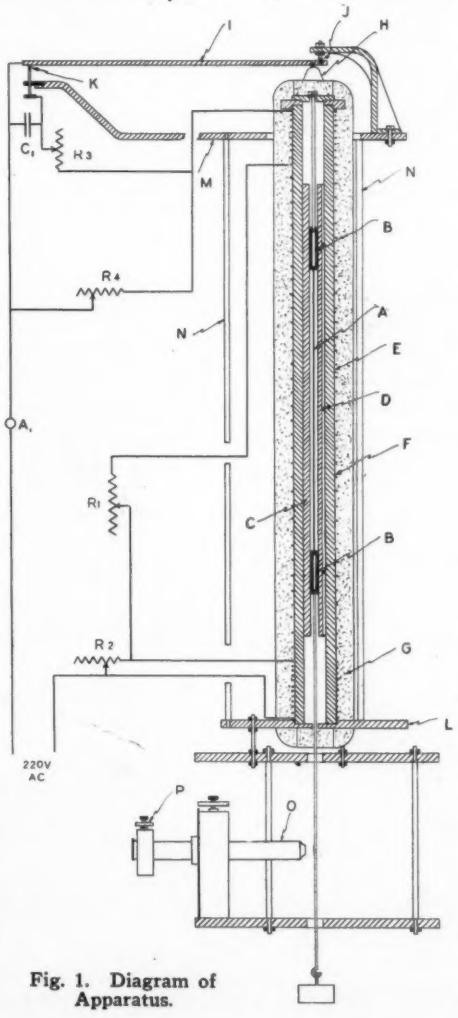


Fig. 1. Diagram of Apparatus.

Discussion of Precision. The viscosity of a fibre elongating is usually computed by means of the following empirical expression:

$$\mu = \frac{L\ m\ g}{3\ \pi\ R^2 E}$$

where μ = the viscosity
R = radius of fibre (cm.)
L = length of fibre (cm.)
E = rate of flow (cm./sec.)
mg = stressing force (dynes)

If the absolute viscosity is to be computed the least precise factor is probably the radius of the fibre R, for an arithmetic mean will not give a correct value if there is any great variation along the length. L and mg can be determined as closely as required. E, the flow rate, depends on the accuracy of extension readings and the time.

The influence of temperature changes on the measurement of rate of flow is twofold: first, on the actual length change due to the expansion of the glass; and

second, the change in flow rate. If we take a specimen 25 cm. long and with a coefficient of expansion of 1 x 10^{-5}, a change in temperature of 1°C. will produce a length change of .00025 cm., an amount larger than

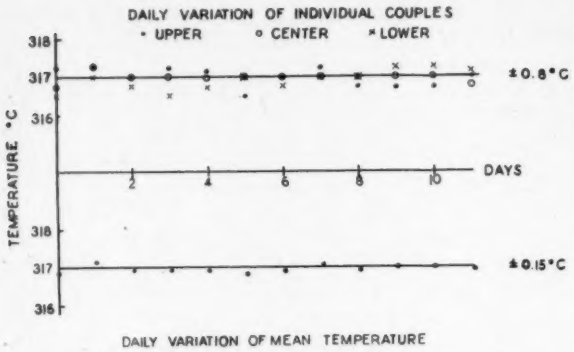


Fig. 2. Uniformity of Temperature Control.

the error of length measurement. Then again an error of 1°C. will cause approximately a 10 per cent change in the flow rate.

From the above discussion it is apparent that our most important factor is the temperature, so that an effort was made in the present apparatus to control it as closely as possible. Not only must the temperature be constant with respect to time but also with respect to position along the specimen; for the correct flow rate is not obtained by running an unevenly heated specimen at a mean temperature corresponding to that of a uniformly heated specimen.

[1] Associate Professor of Ceramics, Mass. Inst. of Technology.
[2] "A New Device for Creep Testing," F. H. Norton and J. A. Fellows, Metal Progress—October, 1933.

Temperature Measurement. With extreme care in calibration and handling base-metal couples, we are sure of our temperatures to within ± .5°C. Platinum couples will give an accuracy of ± .2°C. or about as closely as we know the temperature scale. The cold junctions should be kept in ice and a precision potentiometer used to measure the electromotive force.

Results from this Furnace. In Fig. 2 is plotted the temperature readings taken at 9 A. M. every morning during a run. The individual variations reach a maximum of ± .4°C. and the mean reading for the specimen is ± .15°C. It is found possible in a test of a month's duration to measure viscosities as high as 10^{20} poises

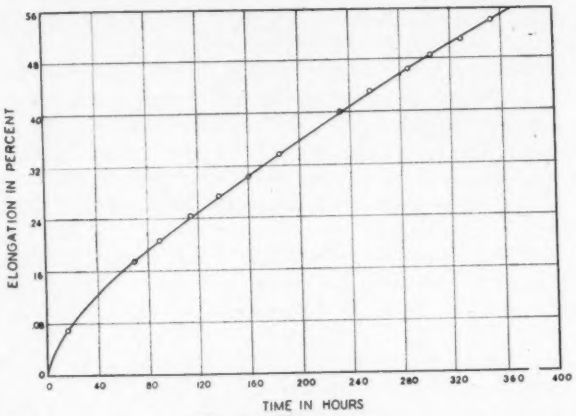


Fig. 3. Flow curve.

with fair precision. A typical extension curve is shown in Fig. 3, but more detailed results of tests made with this equipment will be published at an early date.

USES FOR GLASS

This violet farm in Sussex uses 800 of the bell glasses shown in the illustration. Thanks to their protection the grower can pick 5000 blooms daily eight months of the year.

ALUMINA IN GLASS BATCHES*

By HUGO KÜHL

UP TO our time, Alumina has been a step-child in the glasshouse; wrongly so, because its benefits should have induced the glassmaker long ago to overcome the attending difficulties. These difficulties are those attending the melting of relatively large quantities of pure alumina and, when the fluxes are low, the tendency to stone formation and (in every case) cords. Cords are always due to the incomplete mixing of liquids of different densities; for example, syrup and water. If the batch does not melt evenly and uniformly, we see exactly the same physical affect, and we strive to make the mixture uniform by the ancient method of introducing a volatile substance, such as arsenic.

Alumina was disliked in the glasshouse because it was difficult to melt although it is always a recurring constituent in the old glasses preserved for us because of their favorable composition. Here is an interesting fact which was discovered accidentally before the real reasons were known: Simple soda-lime-silicate glasses do not work well before the lamp. The Thuringian glass blowers, therefore, used a glass made from an aluminous sand. This served their purpose. Going back still further we find the aluminous forest glass. This was made from near-by deposits of sand or marl and resulted in aluminous glasses.

Although glasses of 8 to 12 per cent alumina have been known for a long time, the glassmaker was prejudiced against them for the reasons just mentioned.

My own experience shows that from 2 to 4 per cent alumina can be introduced into the batch if the alkali and lime content are adjusted and if the batch is thoroughly mixed.

Alumina is a constituent of many materials that are of interest to the glass maker; for example, feldspar, clay and ponolith. In these the aluminum oxide is an acid and forms so-called aluminates. This acid characteristic is also present in the glass melt, so we can assume that the alumina in the glass forms calcium aluminate.

It will now be shown in an example that a considerable quantity of pure alumina can be introduced into a glass. Later it will be shown that alumina can be introduced as feldspar.

It must be recorded that the original batch which I melted before the War was not a simple glass but contained three acids and three bases. The batch was as follows:

Sand	57.17%
Boric Oxide	2.79
Alumina	3.07
Soda	20.39
Sodium Nitrate	1.12
Zinc Oxide	5 87
Limestone	10.34
Arsenic	0.28
Manganese Oxide	0.28

Replacing the zinc oxide with an equivalent of lime, and the boric acid with silica, and calculating as oxide, we have:

Silica	70.07%
Alumina	3.54
Sodium Oxide	14.32
Calcium Oxide	11.32
Arsenic	0.28
Manganese Oxide	0.28
	99.81

Normal glass has a composition 75 per cent SiO_2, 12.9 per cent Na_2O, 11.6 per cent CaO. If we consider the alumina as an acid the batch is rather close to the normal. It is somewhat richer in alkali.

The batch containing alumina and zinc oxide furnished a clear, blank glass resistant to temperature change.

It is known that by the use of minerals such as feldspar and ponolith much greater quantities of alumina can be added to the batch without harm to the meltability. These aluminous glasses are especially resistant to pressure and temperature changes.

There is now the question whether the introduction of these minerals will affect the color. It can be said that it is possible to secure minerals low enough in iron to be fully decolorized. Completely iron-free material is not available, and low iron material is scarce. The best Norwegian feldspar has only a trace of iron oxide, one sample showing only 0.08 per cent. Of German material, the lowest iron content is 0.21 to 0.25 per cent. Since we need add only 25 per cent of the mineral of 14.60 per cent alumina content to obtain 3.68 per cent alumina in the glass, the iron content of the glass is only increased to 0.07 per cent and this does not seriously affect the quality or the quantity of decolorizer.

I next melted a batch containing a low iron feldspar instead of pure alumina. This had the following composition: Silica 76.06 per cent, alumina 14.60 per cent, iron oxide 0.21 per cent, alkalis 8.63 per cent. In order to add 3.54 per cent to the glass it was necessary to use 24.24 per cent feldspar. Hence the batch had a composition:

		(Editor's Calculations)
Sand	51.79%	1000. lbs.
Feldspar	24.24	468.
Sodium Oxide	12.23	238.
Calcium Oxide	11.32	218.
Manganese Oxide	0.28	5.4
Arsenic	0.28	5.4
	100.34%	

The batch melted easily and it was colorless. In lustre and refractivity it was on a par with that made from pure alumina. In the above mentioned batch, the zinc oxide was again calculated as lime and the boric acid as silica. The beautiful lustre of these melts was attributed primarily to the zinc oxide. Zinc oxide is used in Belgium to produce very beautiful glasses.

The ease of melting the feldspar batch induced me to reduce the alkali content 1.18 per cent and to repeat the melt. This batch also melted easily, but of course, not so easily as the one higher in alkali. The same re-

* From Glashütte 64, 479-481 (1934)

sults were not obtained with pure alumina instead of feldspar. If the lime content is now raised 1.12 per cent, the melting becomes easy. This strengthens the assumption that calcium aluminate is formed which dissolves in the soda-lime-silicate.

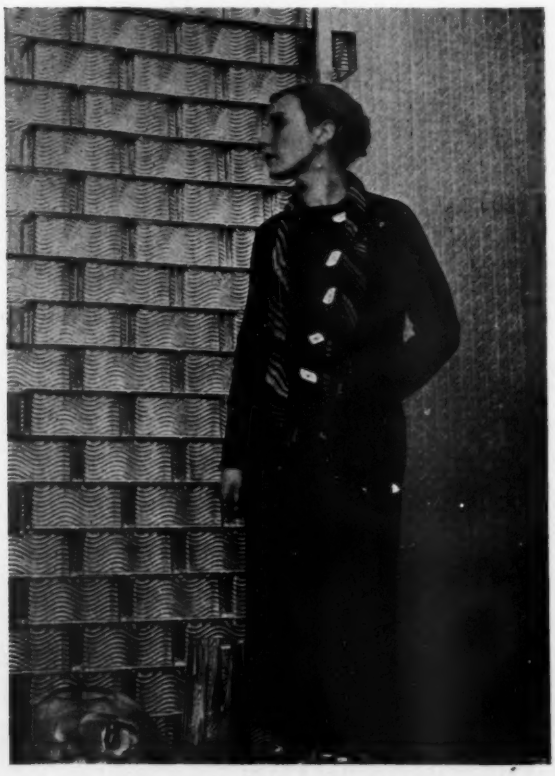
In conclusion, it may be said that it is practical to make glass with an alumina content from 1.5 to 3 per cent using feldspar. Higher Al_2O_3 contents are not necessary and are difficult to work. Such glasses are of good quality, of high strength and are especially suitable for wine bottles.

CORROSION-RESISTANT BUILDING MATERIALS ARE NEEDED

That building materials in large cities are being subjected to defacement and deterioration to an increasing extent as a result of tar and sulphur compounds in the smoke laden air was reported to the American Chemical Society last month by H. B. Meller, of the Mellon Institute. Losses from rust and rot were described as enormous, and pointed to the end of corrosion-resistant building materials. In 1933, said Mr. Meller, the entire output of ordinary steel was just about sufficient to replace that which disappeared through corrosion.

A NEW GLASS BRICK

Trower & Co., London, has recently developed a new cast glass building brick, according to a report sent to THE GLASS INDUSTRY from London. This states that the new glass brick is of normal clay brick dimensions, hollow, with one edge open, and has serrated edges that serve as keys. Two broad surfaces, back and front, are ridged in wavy lines, and these insure translucence without transparency. Heat losses are said to be insignificant and the hollow core provides a light-weight building unit as well as one that is soundproof.



A wall made of the new glass brick.

WINDOWS FRUSTRATE DUST STORMS

Despite a recent radio declaration that an outraged providence sponsored the recent series of dust storms west of the Mississippi, architects and contractors are considering the possibilities of using double glazed or winter windows to combat the terrific toll in damaged home and office furnishings.

Thousands of letters from despairing housewives in states most affected revealed to relatives and friends in more fortunate communities tragic stories of domestic havoc. Cleaners reaped a harvest in restoring window curtains, bedding, rugs and other furnishings, although much of the damaged goods was reported to have been a total loss.

It is argued that winter windows keep out cold air so much more effectively than the ordinary type, according to government statistics, that the same principle would apply to dust storms. The United States Bureau of Standards reveal that double glazing is so effective that fuel savings often are as much as 60 per cent.

The recent experiences in Kansas, Texas, Oklahoma, Colorado and other states were unusually severe but similar disturbances, less damaging are nevertheless somewhat seasonable and costly inconveniences, so that double glazing for summer is considered now by a growing number of home owners as a practical all-year protective idea.

Experts point out that double glazing keeps out cold air far more effectively because of the dead air space between the two panes, and that the hot air of summer is repelled by the same insulating principle.

BITUMINOUS COAL BILL CONTAINS ALARMING PROVISIONS

Smokeless coal operators in Virginia and West Virginia are opposing a bill (S.2481) recently introduced by Senator Guffey of Pennsylvania and favorably reported by the committee, whose purport is stated to be "the stabilization of the bituminous coal mining industry." James Walter Carter, of the Carter Coal Company, writes THE GLASS INDUSTRY that the bill, "if enacted, would have far reaching consequences in raising the price of coal to all consumers". Features of the Bill to which Mr. Carter points with grave alarm are (1) The creation of a vast, government-controlled monopoly; monopolistic, because it limits production under a quota system controlled by a commission, forbids reopening of mines closed since 1929, and fixes prices. (2) Confers immense power upon a single labor organization—the one that can obtain a bare majority—which has the power to establish wage rates and hours of work binding upon all labor. (3) Coerces membership under the code by imposing in effect a 25 per cent tax on non-members, forbidding the Government to purchase from them, closing the mails to non-conformers and forbidding them to trade in interstate commerce. The bill also proposes a federal expenditure of $300,000,000 to purchase coal mines and withdraw them from operation.

METHOD FOR TESTING PRESSURE CONTAINERS UNDER SUSTAINED PRESSURE

IN THE plant control laboratory it is frequently necessary to test the ware (particularly pressure ware) under low sustained pressures. While this may be accomplished by the use of special equipment such as carbonators, the following method which is often used by the bottling industry in testing closures, will be found to be both simple and inexpensive.

In this method advantage is taken of the fact that when sodium bicarbonate is acted upon by an acid such as sulphuric, carbon dioxide is given off and that the same weight of sodium bicarbonate will always give up the same quantity of gas if the pressure and temperature be the same. By the means of the pressure-volume law a series of factors may be calculated that will simplify the determination of the amount of sodium bicarbonate required for any pressure or any size container. For example, the factor for a fifty pound pressure in any bottle is 0.0119 and for a twenty-five pound pressure the factor is 0.00595 (based on temperature of 70°F. and a barometric pressure of 29.4 in.)

The procedure is as follows: The capacity in cubic centimeters to the top of the bottle is first measured; pour into the bottle 25 c.c. of dilute sulphuric acid (3 parts to 2 parts of water by volume). 5 c.c. is then subtracted from the total capacity of the bottle (this is done to allow for the vapor pressure of the liquid and the solubility of the carbon dioxide in the liquid). This figure is then multiplied by the desired factor and the result is the amount of sodium bicarbonate in grams required for the desired pressure.

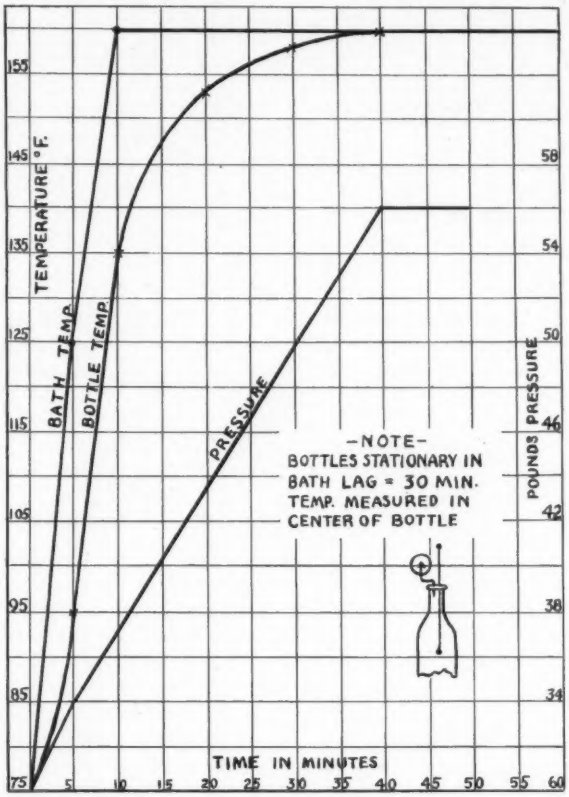
The required amount of bicarbonate is then added to the acid and the bottle quickly capped or sealed with a rubber plunger such as is used in resealing ginger ale. The use of sodium bicarbonate tablets such as are used in the preparation of citrate of magnesia will greatly facilitate the weighing and introduction of the bicarbonate into the bottle. After sealing, the ware is immersed in water to determine if leakers develop and as a safety measure in case the bottle breaks.

The pressures obtained by this method are very close to the theoretical as can be seen from the data in Table 1 in which is listed the measured pressures of a series of bottles under sustained pressures. These measurements were made by puncturing the cover of the cap with a pressure gage attached to a short capillary tube.

TABLE I

Rated Capacity	Capacity to Top of Bottle: Cubic Cent.	U. S. Liq. Ounces	Calculated Pressures 25 Pounds: Bicarb. Used	Pressure Found	50 Pounds: Bicarb. Used	Pressure Found
24	723	24.45	4.28	25.5	8.55	50.5
16	485	16.40	2.85	25.5	5.70	51.0
12	365	12.34	2.14	25.0	4.28	50.5
10	325	11.00	1.91	26.0	3.80	49.5
8	260	8.79	1.55	25.5	3.03	50.0

If it is desired to increase the load (duplication of the treatment the ware receives during sterilization) the temperature of the water bath is increased. Fig. 1 shows the increase in pressure with an increase in temperature in a 12 oz. container. Sustained pressure tests made in this manner will usually require a measurement of the actual pressure in the bottle after the test period is over, if long test periods are used. This is due to the fact that slow leakers sometimes develop. Such measurements are easily and quickly made with a puncture type pressure gage.



SAFETY GLASS SPECIFIED IN NEW GREYHOUND BUSES

About to place an additional 208 new coaches in service, the Greyhound bus lines have taken another step in protecting their passengers by specifying Safety Plate Glass for their vehicles. Each of the new coaches is equipped throughout with safety glass. Greyhound lines in 1934 operated approximately 1614 lines and carried more than 35,000,000 passengers over 42,000 miles of bus routes.

INFORMATION is wanted of NATHAN ARNOWITZ, born in March, 1899, in New York City. He is 5 ft. 9 in. tall, weighs 170 pounds, has brown hair, brown eyes, mole on left cheek, small eyes, long nose. A glazier by trade, Arnowitz last left his wife Reba and their two minor children, Raymond and Rhoda at their home in Brooklyn, N. Y., in December, 1934, since which time he has not supported them and as a result the family is dependent on the bounty of others. Anyone knowing of his whereabouts is requested to kindly communicate with the National Desertion Bureau, 67 W. 47th Street, N. Y. C.

G-E ANNOUNCES METAL RADIO TUBES
PHILCO ADVERTISES "GLASS TUBES ARE BETTER"

THE General Electric Company has announced a new metal radio tube. In a lengthy press release, given to THE GLASS INDUSTRY early in April, the Company makes the claim that the new metal tubes are far superior to those made of glass.

Almost coincident with this release, a full page advertisement was inserted in *The New York Times* by the Philco Corporation, one of the largest radio manufacturers in the country. While the advertisement made no mention of the General Electric Company, its message was obviously directed against the latter's claims for its new metal tubes. "Metal tubes are an old story to us," the advertisement stated in effect, "Metal tubes are a dismal failure—a dead issue."

The statement made by General Electric is given below, almost in its entirety, together with the Philco rebuttal. The former, aside from its general interest, contains statements from which the observant reader may glean considerable practical information.

DEVELOPMENT OF METAL RADIO TUBES ANNOUNCED BY GENERAL ELECTRIC

A new line of metal radio tubes, which tests indicate to be of greater continued efficiency of operation than the glass type now in use, was announced today by the General Electric Company. Developed in the research laboratories of the company at Schenectady, these new metal tubes are not only much smaller and more sturdy, but offer many improved electrical characteristics over the conventional tubes of today. They provide their own shielding and this metal shell is a better heat conductor and radiator than glass. They are particularly advantageous in the field of short wave reception, which in the last year or two has become an important part of all radio receivers. The short leads of the tubes permit greater amplification at the higher frequencies and the more effective shielding insures greater stability.

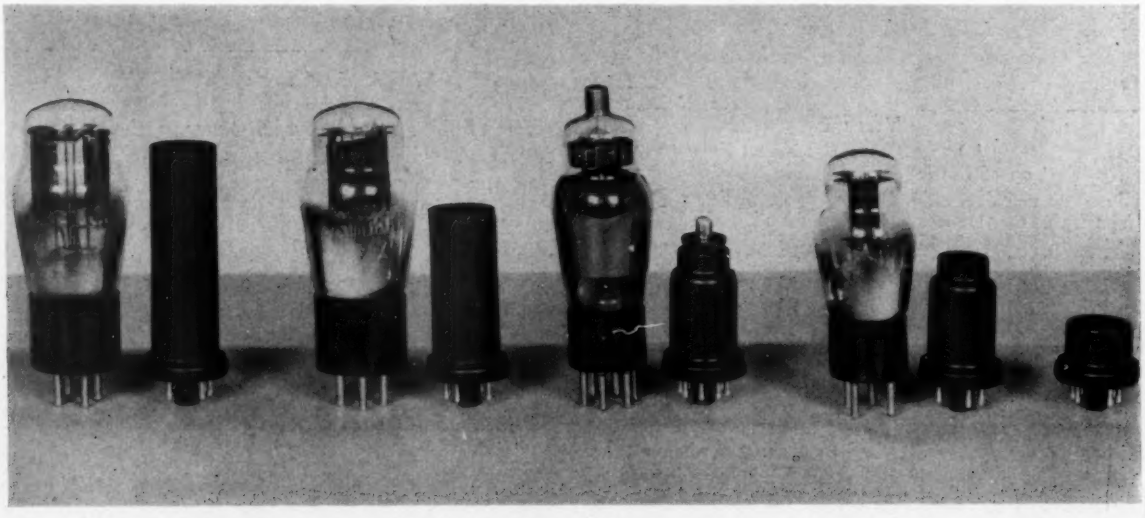
These new tubes are not interchangeable with glass tubes in the present type radio receivers and will make their first appearance in the new fall line of General Electric sets.

The metal tubes are cylindrical in form, some in reduced diameter at the top. Others, such as a radio frequency amplifier, have a terminal at the top extremity. Each lead-in wire passes through the tiny bead of special glass that is fused securely within an alloy eyelet, which in turn is welded to the metal container, thus assuring a long life vacuum. This alloy, having substantially the same coefficient of expansion as glass. is known as Fernico and is a combination of iron, nickel and cobalt. It was developed expressly for this purpose of a perfect seal on the new tubes.

In the main, the new tubes are less than half the size of the familiar glass tubes of corresponding rating. The metal shells are, of course, much stronger than glass bulbs, and not subject to breakage while the use of short stiff supports in the new tubes results in less mechanical vibration of the internal elements.

The familiar metal shield which is necessary with the glass tube in radio-frequency portions of a circuit is no longer required with the new tube. The metal envelope itself serves as a shield. And, since closer proximity of shield to elements can be realized, the shielding is more effective. Whereas, in certain types of glass enclosed screen-grid tubes the anode is shielded first by an internal structure, next by a coating on the inside of the glass bulb, and finally, when in use, by an external "can," in the new metal tube all these functions are performed by the shell.

The new tubes have one more base pin than comparable glass tubes, since the metal envelope has become the shield, and provision must therefore be made to ground



Glass radio tubes and those of corresponding metal, showing the contrast in sizes. (Left to right) rectifiers, power tubes, radio frequency tubes, small triodes, and (alone) the new duo-diode, made only in metal.

this envelope. Designers of the tube have even taken into consideration greater ease of inserting it in the socket. In the present conventional glass tube, two of the base pins are of larger diameter than the others, necessitating alignment of these larger pins with corresponding socket holes. In the base of the new tube, all the pins are of the same diameter, and in the center is a longer insulated keyed pin. By placing this insulated pin in a hole centrally located in the socket, and rotating the tube until the key slips into its groove, the tube is quickly and easily inserted.

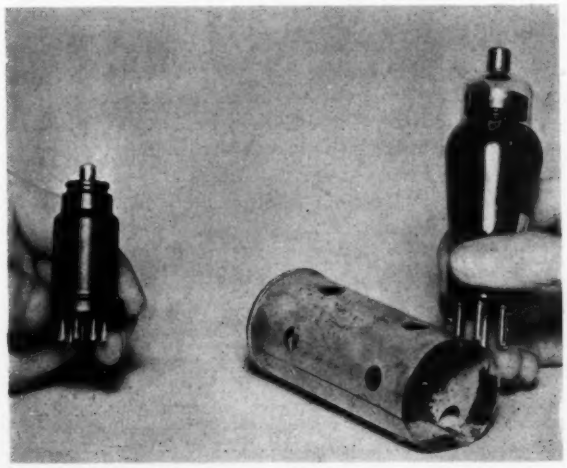
Among the engineering contributions which are cited by General Electric as having helped make the metal tubes possible is a new, sturdy seal to replace the troublesome and expensive feather-edge type of glass-to-metal seal. This glass-to-metal seal, as developed in the General Electric Research laboratory, utilizes a special alloy as before mentioned, the expansion characteristics of which coincide almost exactly with the glass used for sealing. For this reason no stresses are set up in either the glass or the alloy when cooled from the fusion temperature. This lack of initial internal stresses in the completed seal makes it permanently tight and unusually strong.

The new metal technique is applicable not only to radio tubes but to various types of industrial vacuum tubes as well. Large rectifiers, shield-grid Thyratron tubes, and numerous other types have been made with metal construction.

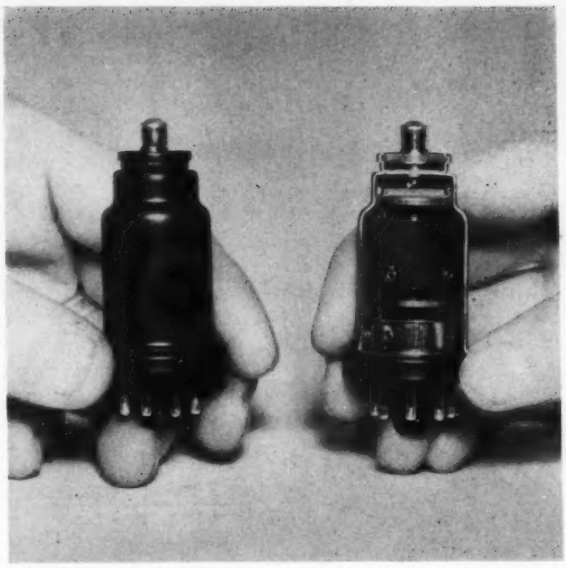
To this, Philco immediately replied via a full page advertisement in *The New York Times*, as follows:

AN ANNOUNCEMENT OF VITAL INTEREST TO EVERY RADIO OWNER . . . AND TO THE RADIO TRADE

In view of recent experimenting with radio tubes, the Philco Radio & Television Corporation believes it is fulfilling its obligation to the public by presenting the facts on this subject, as it knows them, to the American people. These data, presented to radio owners and to the radio industry, are the conclusions drawn from years of research, study, and experience in building 5,500,000 radio instruments. These conclusions, in addition, are based on the experience of the British affiliate of this company, the Philco Radio & Television Corporation of Great Britain, Ltd. They summarize, therefore, the findings of the research and engineering departments of the Philco Radio & Television Corporation both in America and in England.



Contrasting the new metal radio tubes of the triple-grid super-control amplifier type and similar tubes of glass.



An exterior (left) and cut-away view (right) of the same metal tube shown at the bottom of this page.

These findings establish the fact that the glass radio tube is the highest radio performance value today.

This corporation has had first-hand contact with metal radio tubes in England. Metal radio tubes in England were a dismal failure. They are now defunct.

While a metal radio tube might develop possibilities in the future, it is today still in an experimental stage. While the metal radio tube might be of some interest to the public because of the novelty of the idea, its disadvantages are far greater than its present advantages.

The Philco Radio & Television Corporation considers it only the part of wisdom for the American radio industry to proceed cautiously with the introduction of metal radio tubes in this country. The American radio industry should not, in justice to the public, and to itself, rush pell mell into metal radio tubes. The English catastrophe must not be repeated here.

The Philco Radio & Television Corporation engineers and research scientists point out that the American public has available more than forty types of high efficiency glass tubes. These have been brought to their present high state of perfection over many years of scientific research and development. These tubes are giving the public double the performance of a few years ago.

Progress continues on glass tubes; experimentation on metal tubes should be encouraged. Metal may possibly some day take its place alongside glass for radio tubes. In Philco's opinion that day has not arrived as yet. Certainly the American radio industry must not experiment on the public.

Metal, to date, in the opinion of the Philco Radio & Television Corporation offers no worth while improvement over glass in radio performance but does introduce great disadvantages.

HERE ARE SOME disadvantages of metal radio tubes:

1. With the proposed American metal tube construction, bulb size is reduced. With an equal amount of heat to dissipate, the smaller metal tubes must operate at a higher surface temperature than the larger glass tubes.

High temperature is not only detrimental to tube life, but changes the characteristics of nearby coils, resistors, etc., thus impairing the delicate balance of all the various parts of a radio, which is absolutely necessary for fine performance.

This could be avoided by spacing the coils farther away from the metal tubes, but this requires more space, not less.

2. Production difficulties in the proposed metal tubes restrict the manufacture of certain highly desirable multiple function types which are in general use in glass. The proposed metal tubes are limited to a few types—principally single function types.

3. Thus, to achieve a given performance, more metal tubes than glass are required. This again requires more, not less, space in a radio.

4. Also, the additional metal tubes add to cost and electric current consumption without adding to performance.

5. The transparency of the glass often allows the user, or service man, to determine when a tube is not functioning. It is a great help in factory inspection. The inability to see inside a metal tube is a real disadvantage.

6. Loss of vacuum is a serious hazard in the proposed American metal tubes, because, as compared to glass tubes, they require twice as many vacuum seals and each seal is much more intricate. Any air leak at any one of the sealing points in any metal tube stops the radio from working.

Advantages of glass tubes over metal radio tubes today:

1. Present-day highly perfected, high efficiency glass tubes are available in every conceivable single and multiple function type, which allows present-day radio sets to give better performance than was available a few years ago with twice as many tubes.

2. In the wide choice of types of glass tubes, a higher power output of pure tone is available as compared to the proposed metal tubes.

3. Glass tubes are practically fool proof. With all their highly scientific design, breakage in the factory and in service is practically nil. Their ruggedness is attested to by the fact that they are universally shipped installed in their sockets ready for use, and that they withstand transportation by rail, truck, steamship, and loading and unloading, without injury or breakage. Also, millions of radios using glass tubes are in daily use in automobiles and trucks driven over all kinds of roads.

4. Loss of vacuum is practically unknown in glass tubes.

5. In short-wave reception, all experience points to glass as better. The prime requisites in handling short-waves are good dielectric properties and good insulation. Glass is inherently a good dielectric and a good insulator.

PHILCO RADIO & TELEVISION CORPORATION.

General Electric's retort to the above advertisement was in effect: You are talking about foreign metal tubes—we are dealing with the new G.E. tubes, and they are horses of another color. The controversy is waging back and forth, and the final word is still to be said.

JAPANESE IMITATIONS

An interesting example of the extent to which foreign made glass is underselling that made in this country. On the left is an American perfume bottle which is said to sell for 75 cents, and next to it a Japanese copy that costs 20 cents.

FREIGHT INCREASES TESTED IN COURT

Emergency freight rate increases, affecting nearly all glassware and many glass making materials, as well as other commodities, were made effective April 18 by the Interstate Commerce Commission. These increases, however, are being tested in the U. S. District Court of Eastern Virginia. It seems that in petitioning for higher rates, the railroads requested these for specific commodities and did not ask the Commission to grant anything except what was asked. The Commission, however, remanded the railroad order and substituted widely different schedules. The decision, therefore, is now being attacked on the grounds that there has been no showing of their reasonableness. It is impossible to even hazard a guess as to what the court will decide, but a ruling is expected the middle of May. If the I.C.C. order stands, the increases will remain in effect until June 30, 1936, a period of about 14 months.

WANTED: A glass manufacturer who will supply crystal sheet glass from general factory run as follows: Weight—30, 32, 36 and 39 ounces. Size—in first and second brackets. Quantity—carload lots. Will pay cash. Write Box 24, THE GLASS INDUSTRY.

THE GLASS INDUSTRY, 233 Broadway, New York, N. Y.
Enter my subscription to THE GLASS INDUSTRY for one year beginning with the current issue. I enclose $2.00.
Name .....
Street .....
City and State .....

WORLD'S OLDEST GLASS DISCOVERED

By H. H. SLAWSON

DIGGING in the ruins of an ancient Babylonian City, dating almost 5,000 years ago, archaeologists from the University of Chicago have unearthed what is probably the oldest known piece of glass in the world. At a site known as Tell Asmar, some fifty miles from Bagdad, on the Euphrates river, a native pick and shovel man working under the direction of Professor Henri Frankfort, noted archaeologist, recently sifted a small cylindrical object from the dust of ages as he burrowed into the ruins. The cylinder measured barely two inches in diameter and was only half as thick.

When brought to Professor Frankfort, a hasty test was made by scratching the object with a diamond. This indicated the probable nature of the substance and the assumption that it was glass was later proven correct. Professor Frankfort was impressed by the extreme cleanness of the glass and the fact that but few air bubbles were present. He points out that Egypt is often considered the home land of glass making and that opaque glass was fairly common in the ancient world. Clear glass, however, was not introduced before the Roman times. Yet here in Mesopotamia, during a period dated between 2,700 and 2,600 B. C., this cylinder of extremely clear glass comes to light. Nothing as yet has been advanced to explain the phenomenon.

Detailed study of the object was later made by Horace C. Beck, who says:

"If the glass really dates from 2,700 or 2,600 B. C. it is very surprising. Clear blue glass of a very similar color has been found in the Mediterranean, but it shows much heavier corrosion and it is not older than 800 or 1,000 B. C."

Mr. Beck repeated the diamond test on a microscopic chip from the cylinder. He found, also, that the specific gravity of the glass was 2.463 and the refractive index about 1.515. First the chip was immersed in benzine and then in Sira immersion oil and Mr. Beck says, "The glass seemed slightly nearer the latter." Again the chip was tested in benzine and Sira mountant by the shadow method and identical results were produced.

"The specimen from Tell Asmar," he says, "appears to have been modelled or moulded to its present shape and has not been cut out of a solid block. The glass is very pure; has a few small bubbles, but is surprisingly free from striae or inclusions of quartz or dirt.

"Without spectroscopic or chemical analysis it is impossible to say for certain what materials were used, but I should think the alkali was probably soda. The coloring may have been accidental, as it is pale. The clearness of the blue suggests that it is due to copper and not iron; but this, also, should be tested by analysis.

"The coloring matter is carried in the form of small spherical particles which have a slightly blue appearance when a number are seen together in reflected light. These particles are in layers, the majority in the same layer being fairly uniform in size. But those in different layers vary greatly in size. The largest particles are about 1/5,000th of an inch while some layers consist of particles of about 1/25,000th of an inch."

Heretofore, as Professor Frankfort remarks, glass has always been considered a characteristic invention of the Egyptians. Egyptian potters early learned that sand, combined with potash or soda and a metallic oxide, will vitrify at a certain temperature. This knowledge was utilized to produce a glaze for decorative purposes and one of the most absorbing chapters in the history of glass making is concerned with the evolution of the typical Egyptian blue faience found on their pottery from the remotest ages.

The glaze was used also to cover stone, such as the soft steatite from which the well-known scarabs or beetle emblems were fabricated. Pure glass was utilized by the Egyptians in making spherical beads which were usually blue and generally opaque.

More germane to our subject, however, the writer finds a statement made by H. R. Hall, keeper of Egyptian and Assyrian antiquities in the British Museum.

"The invention of glass," says Mr. Hall, "passed from Egypt to the Aegeans; but was probably not generally adopted in western Asia before the time of the 18th dynasty (about 1,580 B. C.) when we also apparently find glazed pottery in Assyria."

Mr. Hall is a recognized authority in the field of Egyptian and Assyrian antiquities, but this statement was made of course, some time ago. Now comes a piece of glass from Babylon, where it was found in a situation that definitely dates it more than fifteen centuries prior to the clear glass mentioned by Mr. Beck as being found in the Mediterranean country. This date, also, is hundreds of years before the earliest known date when Mr. Hall's Assyrians made their first contact with their older neighbors, the Babylonians.

OWENS NEGOTIATING PURCHASE OF LIBBEY GLASS MANUFACTURING CO.

The Owens-Illinois Glass Company, Toledo, O., is reported to be negotiating for the purchase of the Libbey glass manufacturing Company of that city. The Libbey stock has been closely held by four Toledo families, the Libbeys, Robinsons, Richardsons and Donovans. J. W. Robinson is president. The company is a large manufacturer of tumblers, stemware and cut glass. About two years ago it developed a thin blown type of tumbler, with a safety rim, which is completely revolutionizing that particular type of packers' ware. No details of any negotiations between Owens and Libbey have received official confirmation, but they are believed to be definitely instituted.

W. C. FORBES DIES

Word of the death of Mr. W. C. Forbes, president of the Foster-Forbes Glass Co., Marion, Ind., reached THE GLASS INDUSTRY too late for our issue last month. Mr. Forbes died at the Passavant Memorial Hospital on the evening of April 1 as the result of a severe operation. In his passing, the glass container industry has lost one of its most prominent leaders, and a man who had endeared himself to all. To his family who survive him, THE GLASS INDUSTRY extends its warmest sympathy.

SOCIETY OF GLASS TECHNOLOGY

On Wednesday, April 3, members of the London Section of the Society of Glass Technology inspected the Rubber Exposition at the Science Museum, London. By way of preparation for the visit, the Section attended a lecture on the modern technical and industrial developments of the rubber industry, given by T. R. Dawson of the technical staff of the British Rubber Manufacturers Association. Members then visited the Exposition where they saw the story of rubber from its growth to its finished products depicted by the exhibits.

On May 1, a meeting was held at Messrs. Holophane, Ltd., which took the form of a "question box". Previous to the meeting, members submitted their questions to a committee. The committee selected certain of these and read them at the meeting, without divulging the name of the contributor.

The Society of Glass Technology held its 18th annual general meeting in Sheffield on April 10. The following officers were elected: Bernard P. Dudding, president; F. C. Flint, American treasurer; and Prof. W. E. S. Turner, honorary secretary and editor.

At the 170th ordinary meeting which immediately followed, two papers were presented:

The Purification of Sands, by F. W. Adams.

In this paper mention was made of the origin of sands and of the types of impurities which occurred in them likely to affect their suitability for the manufacture of colorless glass. Attention was mainly directed to British sand deposits with particular reference to the amount and occurrence of their iron oxide content.

A short account was given of several chemical methods which had been tried in the past for treating sands to reduce their iron oxide content sufficiently to render possible their use for the manufacture of good quality white glass.

The investigations which led to the development of the process outlined in the paper were described; also the results obtained by its use on various types of sand.

For this process dilute solutions of acid oxalates were used together with small quantities of ferrous sulphate. The sand to be treated was agitated for a short time with a solution, containing these two chemicals, at a temperature of 26° to 65° C.

The Effect of the Addition of Small Amounts of Volatile Salts upon the Viscosity and Surface Tension of a Molten Soda-Lime-Silica Glass, by A. E. J. Vickers.

The investigation was undertaken in order to obtain some exact information as to how the addition of such substances as ammonium sulphate, salt cake, borax, sulphur, etc. affected the viscosity and surface tension of a glass.

Various methods were tried and finally the method of L. Margules was used for the measurement of viscosity, and a modification of the method due to L. Wilhelmy was adopted in the determination of surface tension.

A glass of the following percentage composition was used, namely: SiO_2, 75.66; Al_2O_3, 0.74; CaO, 9.89; MgO, 0.18; Fe_2O_3, 0.04; Na_2O, 12.90; K_2O, 0.18; SO_3, 0.01. To this, salts were added in the following quantities—salt cake 10 parts, ammonium sulphate 10 and 15 parts, and sodium nitrate, 10 parts, per 1000 parts of sand; also borax to give B_2O_3 of 0.7 per cent and sulphur. In each case of a salt addition the composition of the batch was adjusted so that the final glass always had the above composition with the exception of borax, in which case adjustment was impossible owing to the non-volatility of the borax.

All the salts tried produced a decrease in the viscosity of the glass over the normal working range of temperature, ammonium sulphate and borax being especially active in this respect. The use of borax gave a glass of rather different character to the plain glass taken as the standard of comparison. With ammonium sulphate, the final glass was of identical chemical composition to that taken as the standard.

In the case of surface tension, the general effect was to lower the value, but the decreases obtained by the use of ammonium sulphate, borax and sulphur were unexpectedly large. A lowering of the surface tension would result in a very large increase in the rate of wetting of the batch, and hence would help in the glass melting process.

BELGIAN TARIFF TREATY

No sensational developments have occurred as a result of the signing of the reciprocal treaty with Belgium by President Roosevelt, and it is expected that the present situation will remain about the same. At the time of signing the treaty, President Roosevelt issued a proclamation separating foreign nations into three groups in so far as their trade with the United States is concerned.

In separating the sheep from the goats for "most favored" nation tariff agreements, members of the glass industry will be interested to note that Czecho-Slovakia and Japan, leading competitors of the United States, as pointed out in the April GLASS INDUSTRY, are listed among the goats. These two countries will enjoy the Belgian rate temporarily; but they may at any time be notified that this privilege has ceased, subject, of course, to such obligations as we may have under existing treaties. This new policy of the President in a sense modifies and limits the "most favored nation" doctrine, the Administration's statement to the contrary notwithstanding, and paves the way for a plan of swapping concessions with nations willing to grant us equal favors in return. Such a policy would be of definite benefit to industries who are being traded for concessions, as they would no longer be subject to the perils of the most favored clauses.

THIRD CONFERENCE ON GLASS PROBLEMS

The Department of Ceramic Engineering at the University of Illinois announces that plans are being made for holding a Third Conference on Glass Problems to take place about June first at Urbana, Illinois. It is expected that the program will include some very interesting papers on glass tank operation, glass tank insulation, and the use of cullet. A questionnaire dealing with these problems is being prepared for distribution and it is hoped that there will be a prompt and full cooperation by those to whom it is to be mailed.

A capable representative with a good knowledge of the glass business is wanted to sell table glass, fancy articles, electric lighting articles for the largest glass plant in Poland. Write or call at the American Polish Chamber of Commerce, 151 East 67 Street, New York City.

NEW LYNCH FACTORY A MODEL OF EFFICIENCY

To enable glassmen scattered over every corner of the world to see how and where Lynch forming machines are made, Lynch Corporation, Anderson, Indiana, has had a picture taken of its magnificent new factory building—said to be the largest factory building whose output serves exclusively the glass industry.

The main factory building provides over 52,000 square feet of floor space on a single floor. Construction is brick and iron. The saw tooth roof, fenestra type windows, and walls painted in white enamel, provide exceptionally fine lighting and the best of working conditions. The floor is of concrete, and this with the roof construction, permits the use of any and all types of material handling equipment, including overhead traveling cranes and lift trucks.

Production starts at the raw-stock department, a separate building opening into the far end of the plant. Castings are weighed as they are received, checked, and placed in bins. Bar stock follows a similar procedure, and racked according to size.

The machine department is fitted with the most up-to-date machine tools, some of which may be seen in the accompanying illustration. After being machined, parts are delivered to the inspection department, and after a very rigid inspection are either passed along to the stock room or returned for a re-working.

The stock room, 60 x 80 feet, is so enclosed that only those who have a direct connection with the department can gain admittance. Bins, shelves and racks are numbered up to 10,000, not counting the various prefixes and suffixes. Lynch parts are carried in one location, O'Neill in another, and Miller in still a third.

The Lynch factory is served by both the Pennsylvania and New York Central lines, and is most centrally located with respect to all important glass making centers of the United States.

ANNUAL G. C. A. MEETING

The Glass Container Association will hold its annual meeting at The Greenbrier, White Sulphur Springs, from May 8 to 10 inclusive. The convention will follow closely the pattern of former years—the Board of Directors meeting the preceding Tuesday, the Cap and Closure Division on Wednesday, a general meeting of the entire Association and allied industries on Thursday, and the Glass Division, Friday.

The Association always strives to emphasize the social nature of its spring meeting, so as to make it as far as possible a get-together of its members on an entirely different basis than is possible at other times during the year. The program committee this year is made up of I. R. Stewart, E. F. Brundage and Robert H. Swindell. The golf tournament on Thursday afternoon will be a novelty affair, of the bingle, bangle, bungle variety, details of which will be announced on Thursday morning. Mr. Stewart has arranged an entertainment to follow the banquet that evening, which is promised to eclipse even the splendor of last year's great performance.

Special provision is being made for the ladies, who will be entertained at Tea and Bridge by Mrs. Roydon Blunt on Thursday, while the golf tournament is in progress. A dance will also be held at the conclusion of Thursday night's floor show to which all guests of the Association attending the convention are invited.

Looking down a section of the new Lynch Corporation factory, Anderson, Indiana. Note the wiring system overhead, by which it is possible to move any machine to a new location or put a new machine in service without any delay whatever. The factory is a model in construction and general all around efficiency.

HEATING UP GLASS TANKS

(*Continued from page* 136)

bottom must be carefully let out and watched for wide joints. In one instance, a new tank bottom had been exposed to rain and during the heat-up the absorbed water was driven out as steam. Suddenly the blocks seemed to become dry and the expansion was so rapid that the men were unable to keep up with it and one large bottom rod was jammed tight. Extra long wrenches, hammers and a dozen other expedients were tried but without avail. Finally, it was necessary to heat the rod with an acetylene torch and, when it became red hot, it suddenly necked and the strain was released so that the nut could be loosened. Under unfavorable conditions there was a possibility of the bottom buckling upwards.

Flux block jack bolts at the corners of the tank must be kept loose or they will jam in a surprisingly quick time. Corner joints usually open up and must be kept within reason by using a jack if necessary.

As the tank heats up, fires must be adjusted and changed. Pipes begin to bend and must be pulled back. Care should be exercised when changing or moving a fire so as not to overheat a part of the tank which hitherto has been comparatively cool.

The stack should be used as early as possible, perhaps at about 600 to 800° F., with all reversing valves on center and all openings closed to keep out the cold air. This will pull the heat gradually into the ports and regenerators. Use only enough stack to keep the tank clear so that the gas will burn; too much will pull in cold air through every door and crack in the tank. If the stack is fired with wood and the pull is irregular it can be evened considerably by first wetting the wood.

If there are both air and gas regenerators, the middle or inside damper should be open so as to heat both chambers equally and avoid cracking the dividing wall by uneven expansion.

Reversals at about one or two hour intervals can be started at about 800°-1000° F. so as to heat up both regenerators equally. Again the amount of stack pull must be adjusted so as not to pull in more cold air than is required for good combustion. At about 850° F. the soot will begin to burn off the crown and at 1200°-1300° F. the glass in the melting end will begin to soften.

Reversals can be speeded up to thirty-minute intervals at 1500° F. and at about 1600°-1700° F., the regular port burners can be used with regular reversals, as the expansion will be almost complete and the gas will ignite easily on the hot brick work. With producer gas, it is advisable to place a stick of wood in each port mouth and have them burning before the gas is turned on so that it will be certain to ignite.

After this, the tank should be tucked up and the expansion joints permanently closed as early as possible. Cullet fills should be started only after the tank is heated throughout at the maximum temperature. Batch fill should not be put in until the level is well up and certainly not before the flow hole in the bridge is covered or, if floaters are used, until they are properly set.

The last job which a careful operator will do will be to put all the tools necessary for the heating-up job in a place where they can be found when needed.

Finally, a few words will not be amiss regarding the cooling off of a tank. This job is only too often sadly neglected with resultant damage to crowns and blocks. As soon as the last charge is completely melted or the tank drained down to the level desired and the fires turned off, all dampers should be dropped and all tank openings closed tight to prevent cold air from entering.

The rods should be gone over and kept tight, as the crown shrinks. At the same time the side wall flux block jack bolts should be loosened as the buckstays are pulled in, to avoid cracking any blocks or tipping them into the tank.

Any part of the tank exposed to a wind should be protected to avoid sudden chilling of the flux blocks. These precautions are well worth the effort required as the tank will be in vastly better condition, when it is again to be heated up.

MIN-OX
RESISTS SCALE

Regarding Moulds . . . . . .

Only experienced metallurgy and intimate knowledge of glass making can solve glass mould problems. The personnel of The Binney Castings Company joins metallurgical distinction with actual glass production experience.

MIN-OX Castings:—a series of alloys to meet varying glass production requirements.

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Toledo, Ohio

Originators Of Alloys For Glass Moulds.

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Transparent Colored Blown Sheet Glass
Solid Pot Opal Blown Sheet Glass
Flashed Opal Blown Sheet Glass
Colonial Antique Colored Glass
Heat-Ray Resisting (Cool Glass)
"TWIN-RAY"—
the scientific
illuminating
glass.

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"IF ITS MADE OF GLASS, ASK US FIRST"

EQUIPMENT AND SUPPLIES

C. P. OVERMYER OFF TO PACIFIC COAST

C. P. Overmyer, president of the Overmyer Mould Company, Winchester, Indiana, is leaving the middle of May on a four week business trip to the Pacific Coast. His itinerary will take him through Redcliffe, Alberta, into Vancouver, and he will call on the glass trade in San Francisco, Los Angeles and other Coast cities. The return trip will include stops in Oklahoma and Mississippi.

S. A. FORTER OPENS PITTSBURGH OFFICE

S. A. Forter has announced the opening of an office in the Martin Building, 119 Federal Street, N. S. Pittsburgh where he will specialize in general glass factory engineering and construction. Mr. Forter is well known to the glass industry, having been connected with the H. L. Dixon Company since 1918.

BAILEY ANNOUNCES NOVEL FUEL-AIR FLOW METER

The Bailey Meter Company, Cleveland, announces a new Fuel Flow-Air Flow Meter, designed to provide furnace operators with an easily understandable guide by which they can maintain a definite relation between the amounts of air and fuel supplied to the furnace and thereby secure full combustion economy. The meter contains two recording pens, one recording the oil or gas flow and the other the air flow. At the time the meter is installed, a complete combustion test is made to determine the proper ratio, and when this is determined, the mechanism of the meter is adjusted so that the two records will coincide, one upon the other, when best combustion conditions are maintained.

CHAINS AND SPROCKETS

The C. O. Bartlett & Snow Company's bulletin No. 74, Chains, Sprockets, Buckets, is available for distribution. Standard types of Detachable, Pintle, Ley Bushed, Combination, Drag, Roller, Transfer, Steel Bushed and Drop Forged Chain and Chain Attachments are illustrated, and the dimensions, weights, working loads and prices are given for each size. Eighteen pages are devoted to listings of prices and weights of sprocket wheels. Information is given on sizes, prices, etc., of Shafting, Collars, Takeups, Elevator Buckets, and Spur, Mitre, Girt and Bevel Gears. Copies are available on request.

MOVE TO NEW QUARTERS

W. N. Best Co., makers of burners for melting furnaces, lehrs and sand driers, have moved from 39 Cortland St. to more modern quarters at 75 West Street, New York City.

CATALOGS RECEIVED

Crushers and Pulverizers for the Laboratory. American Pulverizer Company, St. Louis, Mo. Describing and illustrating small crushers designed for laboratory use in the grinding of various materials.

Bulletin 60. The Pyrometer Instrument Co., New York. Illustrates and describes the new Pyro surface pyrometer recently placed on the market.

"Steam Costs Go Down." Folder 1459. Also *"The Heating Plant Pays a Profit."* Folder 1458. Link-Belt Co., Chicago. Contain data on underfeed screw-type stokers in sizes up to 300 B.H.P. Illustrated.

Bucket Elevators. Catalog No. 565. Jeffrey Manufacturing Co., Columbus, O. A 112 page catalog covering a broad field of elevator requirements, and including an increased number of vertical space type Centrifugal Discharge elevators, with the buckets mounted on chain or belt, and a line of heavy duty Continuous Bucket elevators in castings. Chapter I of the catalog covers fundamentals of design, application and operation, helpful to the engineer in selecting the elevator type best suited to his requirements.

Brown Potentiometer Pyrometers. Brown Instrument Co., Philadelphia.

An illustrated folder describing the advantages of this equipment.

O. HOMMEL'S NEW SPRAY MACHINE

O. Hommel Company, Pittsburgh, Pa., has developed the "Duquesne" Flat Spray Machine, said to be the first small sprayer, with cup attached and without a needle, to have a flat spray. It is designed to handle heavy liquids, such as enamels, glazes, lacquers, etc., and covers large surfaces quickly and easily.

F. E. MILLER RECOVERING

F. E. Miller, secretary and treasurer of the Miller Foundry Company, Columbus, O., is recovering from the severe injury he received last January, when he fell down an unprotected elevator shaft in a downtown garage. It was found that he had crushed two vertebrae in the lower part of his back, necessitating his being confined to a hospital for over two weeks. Mr. Miller is now able to move about and spend a few hours each day at his office, and it is expected that he will be completely recovered by the end of this month.

LEEDS & NORTHRUP ANNOUNCE AGREEMENT

An agreement, applying only to the sale of industrial electro-chemical instruments and certain types of flowmeters, has been consummated between Leeds & Northrup Company of the United States and George Kent, Ltd. of Great Britain. Under this agreement, Kent will not offer its industrial electro-chemical instruments or its flowmeters for sale in the United States or Canada unless through Leeds & Northrup, while Leeds & Northrup will not offer its similar instruments for sale in the British Empire (except Canada) unless through Kent. Neither the sale, in the States by Builder's Iron Foundry, of Kent venturi and shunt type rotary meters, nor the sale anywhere by either company or its agents, of products other than those specifically mentioned is in any way affected.

Etchall, a new product for etching glass by a simple, quick and inexpensive process, has been announced by the Pine Consolidated Corporation, New York City. The compound is applied with a brush and stencil and requires two minutes to etch a monogram, design, serial number or other device upon a piece of glass.

CURRENT PRICES OF GLASS-MAKING MATERIALS

FURNISHED BY PRODUCERS, MANUFACTURERS AND DEALERS

		Carlots	Less Carlots
Acid			
Citric (dom.)	lb.	...	.29
Hydrochloric (HCl) 20° tanks ... Per	100 lb.		1.10
Hydrofluoric (HF) 60% (lead carboy)	lb.	...	.13½
52% and 48%	lb.	.10	.10-.11½
Nitric (HNO_3) 130 lb. carboy ext. Per	100 lb.	...	5.50
Sulphuric (H_2SO_4) 66° tank cars	ton	15.50	...
Tartaric	lb.	... Po. or Gr. / Cry.	.25 / .25½
Alcohol, denatured, 50 gal. drum	gal.	...	.56½
Aluminum hydrate (Al (OH)₃)	lb.	.04-.04½	.04½-.05
Aluminum oxide (Al_2O_3)	lb.	.04	.05
Ammonium bicarbonate (f.o.b. works)	lb.	.0515	...
(f.o.b. N. Y.)	lb.	...	.0571
Ammonium bifluoride (NH_4FHF)	lb.	...	.15
Ammonium nitrate (NH_4NO_3)	lb.	...	.08
Ammonia water (NH_4OH) 26° drums	lb.	...	.02¾
Antimonate of Sodium	lb.	...	.10½
Antimony oxide (Sb_2O_3)	lb.	...	.12¼
Antimony sulphide (Sb_2S_3)	lb.	...	.11
Arsenic trioxide (As_2O_3) (dense white) 99%	lb.	.03½	.04-.04½
Barium carbonate ($BaCO_3$), Crude, (Witherite) 90%, 99% through 200 mesh	ton	40.00	45.00
90% through 100 mesh	ton	37.00	...
Barium hydrate ($Ba(OH)_2$)	lb.	.049	.05½
Barium nitrate ($Ba(NO_3)_2$)	lb.	...	.07¼
Barium selenite ($BaSeO_3$)	lb.	...	1.50-1.75
Barium sulphate, in bags	ton	19.00	24.00
Barium sulphate, glassmaker's, carlots, bulk f. o. b. shipping point	ton	15.00-16.00	18.00
Bone ash	lb.	.06	.06½
Borax ($Na_2B_4O_7 10H_2O$)	lb.	..	...
Granulated In bags,	lb.	.02	.02¼-.02½
Powdered In bags,	lb.	.02¾	.02½-.02¾
Boric acid (H_3BO_3) granulated In bags,	lb.	.04¼	.04½-.04¾
Cadmium sulphide (CdS)—	lb.		.70-.75
Calcium phosphate ($Ca_3(PO_4)_2$)	lb.	.07	.07½
Chromite	lb.	...	.0215
Cerium hydrate 100 lb. drums and 600 lb. barrels	lb.	...	.65
Chrome Oxide Green, 400 lb. bbls.	lb.	...	.215-.25
Cobalt oxide (Co_2O_3) In bbls	lb	...	1.25
In 10 lb. tins	lb.	...	1.35
Copper oxide Red (Cu_2O)	lb.	...	.25
Black (CuO)	lb.	...	.15
Black prepared	lb.	...	.22
Cryolite ($Na_3Al\ F_6$) Natural Greenland (Kryolith)	lb.	.08½	.09
Synthetic (Artificial)	lb.	.08½	.09
Epsom salts ($MgSO_4$) (imported) technical	Per 100 lb.	...	2.30
Feldspar— 20 mesh	ton	10.00-12.25	
40 mesh	ton	10.50-12.75	
Granular	ton	10.75-13.00	
Semi-granular	ton	10.00-12.25	
L. C. L., (Min. 2 tons) $3.00 per ton additional plus charge for bags			
Fluorspar (CaF_2) domestic, ground, 96-98% (max SiO_2, 2½%) Bulk, carloads, f. o. b. mines	ton	25.23	...
In bags	ton	26.83	38.00-40.60
Formaldehyde, bbls.	lb.	...	.07
Graphite (C)	lb.	...	.04-.07
Iron oxide— Red (Fe_2O_3)	lb.	...	.0425
Black (Fe_3O_4)	lb.	.04½	...
Iron chromate	lb.	..	.035-.05
Kaolin (f. o. b. mine)	ton	8.00-9.00	...
English, lump, f. o. b. New York	ton	14.50-25.00	24.50-30.00
Kryolith (see Cryolite)			
Lead chromate ($PbCrO_4$)	lb.	...	.16
Lead oxide (Pb_3O_4) (red lead) (N. Y.)	lb.	.062	...
In 5 Ton lots	lb.	...	.065
Less than 5 Tons	lb.	...	.07

		Carlots	Less Carlots
Lime—			
Hydrated ($Ca(OH)_2$) (in paper sacks)	ton	10.50	...
Burnt (CaO) ground, in bulk	ton	7.00	...
Burnt, ground, in paper sacks	ton	9.00	...
Burnt, ground, in 280 lb. bbls	Per bbl.	2.25	2.25
Limestone ($CaCO_3$)	ton	1.75-2.50	
Litharge (PbO) (New York Prices)	lb.	.0525	...
In 5 Ton lots	lb.	...	.055
Less than 5 Tons	lb.	...	.06
Magnesium carbonate ($MgCO_3$)	lb.	.06	.08-.09
Magnesium sulphate (U.S.P.)	lb.	...	.03
Manganese, Black Oxide In Paper bags	ton	45.00	50.00
In Burlap bags	ton	46.50	51.50
In Casks	ton	48.00	53.00
Neodymidm oxalate, 50 lb. drums	lb.	...	5.00
Nickel oxide (Ni_2O_3), black	lb.	...	.35-.40
Nickel monoxide (NiO), green	lb.	...	.35-.40
Plaster of Paris, bags	ton	31.00	23.00-29.00
Potassium bichromate ($K_2Cr_2O_7$)— Crystals	lb.	...	.08½
Powdered	lb.	...	.09½
Potassium carbonate Calcined (K_2CO_3) 96-98%	lb.	.07½	.07½
Hydrated 80-85%	lb.	.06¼	.06¾
Potassium chromate (K_2CrO_4) 450 lb. bbls.	lb.		.16
Potassium hydrate (KOH) (caustic potash)	lb.	.06¼-.06½	.08-.08½
Potassium nitrate (KNO_3) (gran.)	lb.	...	.06-.06¼
Potassium permanganate ($KMnO_4$)	lb.	...	.19
Powder blue	lb.	...	.17-.18
Rare earth hydrate 100 lb. drums	lb.	...	.35
325 lb. barrels	lb.	...	.30
Rochelle salts, bbls	lb.	...	.12½
Rouge	lb.	... Po. or Gr. / Cry.	.13½
Rutile (TiO_2) powdered, 95%	lb.	.10-.12	.13-.15
Salt cake, glassmakers (Na_2SO_4)	ton	18.00	27.00
Selenium (Se)	lb.	...	2.00-2.10
Silver nitrate ($AgNO_3$) . (100 oz. bot.) per	oz.	...	.39
Soda ash (Na_2CO_3) dense, 58%— Bulk	Flat Per 100 lb.	1.10	...
In barrels	Per 100 lb.	1.50	...
In bags	Per 100 lb.	1.25	...
Sodium bichromate ($Na_2Cr_2O_7$)	lb.	.06½	.06¾
Sodium chromate ($Na_2CrO_4 10H_2O$)	lb.	...	.08
Sodium fluosilicate (Na_2SiF_6)	lb.	.04¼	.05¼
Sodium hydrate (NaOH) (caustic soda) Flake	Per 100 lb.	3.00	...
Solid	Per 100 lb.	2.60	
Sodium nitrate ($NaNO_3$)— Refined (gran.) in bbls.	Per 100 lb.	...	2.00-2.25
95% and 97% Bulk	Per 100 lb.	1.175	...
200 lb bags		1.24	1.29
100 lb. bags		1.275	1.325
Sodium selenite (Na_2SeO_3)	lb.	..	1.80-2.00
Sodium uranate (Na_2UO_4) Orange	lb.	...	1.50-1.55
Yellow	lb.	...	1.50-1.55
Sodium uranyl carbonate	lb.	...	.80-.90
Sulphur (S)— Flowers, in bbls	Per 100 lb.	3.35	3.70-4.10
Flowers, in bags	Per 100 lb.	3.00	3.35-3.75
Flour, heavy, in 250 lb. bbls.	Per 100 lb.	2.90	3.25-3.65
Tin chloride ($SnCl_2$) (crystals) in bbls.	lb.	...	.38
Tin oxide (SnO_2) in bbls	lb.	...	.53
Uranium oxide (UO_2) (black, 96% U_3O_8) 100 lb. lots. Black	lb.	...	3.00
Yellow orange	lb.	...	1.60
Zinc oxide (ZnO) American process, Bags	lb.	.0575	.06
White Seal, 150 lb. bbls.	lb.	.10½	.10¾
Green Seal bags	lb.	.09½	.09¾
Red Seal, bags	lb.	.08½	.08¾
Zircon Granular (Milled .005-.02c higher)		.07	.67½-.08
Crude, Gran. (Milled .005-.02c higher)		.03½	.04-.0

MACHINE LUBRICATION

There is an expression "nothing has a more direct bearing on the life of a machine than lubrication." Nothing could be more true. Let us apply this to glass forming and fabricating machines.

The driving mechanism, including the Geneva rotator, usually operate in an oil bath, in which case the various working parts function in close proximity to the accuracy of the machine. For this part of the machine an oil of SAE No. 50 specifications should be used. If the oil is not selected specially for this purpose, it may be too heavy, in which case the motor will heat up or require more power to rotate the machine.

The table which carries the molds, when it is of the revolving type, is mounted on ball bearings of the thrust type. Lubrication of these parts can be satisfactorily accomplished with either oil or grease, according to the housing design.

With grease, housings should preferably be filled not over one-third to one-half full, the grease level being just above the top of the lowest ball. If the housing is full, there is a tendency for the grease to churn and generate heat due to internal friction; this causes melting, which further aggravates the churning and heating and causes the grease to leak out of the housing. Where the grease is forced in by pressure, the housing will frequently be so full as to force the grease out even before the machine is operated.

Best results, however, are obtained by a study of individual conditions and the ideal lubrication of bearings is either a circulating oil in very small volume or a splash system where the bearing is not in the oil at all, but runs in a mist created by some sort of slinger. When oil is used to lubricate the bearings it should be fed at a rate under which the oil to some extent, also serves as a cooling medium.

On the modern glass machines, the air cylinders and other pertinent parts with which the air comes in contact are lubricated by impregnating the air with oil as it enters the machine. To accomplish this, a sight feed lubricator is usually installed in the main air supply line. In this way, the oil can be fed drop by drop into the air stream, so that as it passes through the machine it will carry sufficient lubricant to serve the valves and cylinders.

Oil used in lubricators should be good, clean, clear oil—an oil that will emulsify and mix with moisture and at the same time resist the congealing effect that result from changes in temperature. Proper lubrication can be secured by using a compounded oil with reasonably low cold test properties, refined to meet this particular condition. By using a compounded oil, the slight lather effect produced leaves behind it an oil coating that will prevent rust from forming when the machine is idle.

During the operation of glass machines the molds are sprayed frequently and swabbed periodically to prevent sticking of the article in the mold. If the oil is not selected specially for its low carbon content there is a possibility that carbon residue will accumulate on these parts and more frequent cleaning would be necessary. For this purpose, use a paraffine base oil about 100 viscosity and 27 gravity. Many economies will result from the proper selection of oil and grease for lubrication.

ANDREW G. DOLL.

K & B Wind System for cooling tank blocks on glass furnaces. Note new vertical cast aluminum nozzle—one of the K & B improvements that insures maximum efficiency.

***Modernize* and *Economize* with K & B Wind Systems**

Because of modern design and engineering, including a number of exclusive advantages, K & B Wind Systems reduce cooling costs by saving power and increasing tank life.

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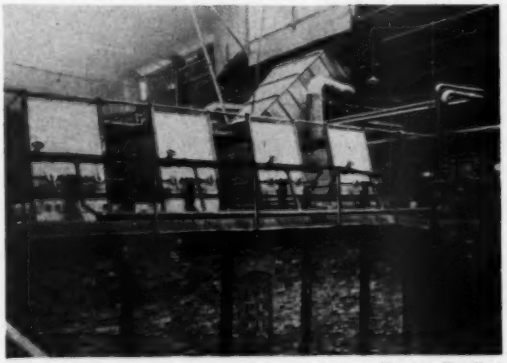
PLATE GLASS COMPANY

Refractories Division

GRANT BUILDING, PITTSBURGH, PA.



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The Controlled Luminous flame method of firing offers the following advantages:

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3. Increase in Furnace Tonnage
4. More Homogenous Glass
5. Adaptability to continuous tanks and POT FURNACES.

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958 Wall Street Toledo, Ohio

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MOULD CASTINGS
Quality and Quick Service
....250 EMPLOYEES
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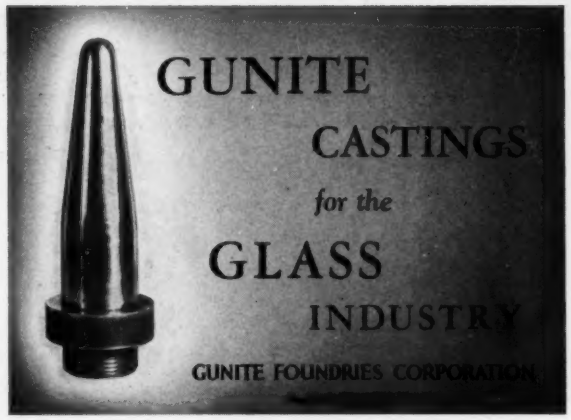

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